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INCANDESCENCE LIGHTING.

In the paper on "Electrical Lighting by means of Low Resistance Glow Lamps," read before the Society of Telegraph Engineers by Mr. Bernstein a fortnight ago, the new term "*strain*" was introduced to describe the condition of an incandescence lamp when, for the expenditure of a certain number of watts we have a certain candle-power. "Strain" is defined by the author as the reciprocal of the number of watts required per candle, and, speaking for ourselves, we can think of no happier term in which to express the relation between candles and watts. According to the new terminology, when the lamp is worked at a high strain, say ·4 candle per watt, its life is short: conversely, when the strain is reduced the life of the lamp is lengthened. In this article we shall in future talk of a strain of ·1, ·2, &c., candles per watt always being understood.

Some of the members present at the meeting to which we refer objected to the new term "strain," and proclaimed in favour of the older term "efficiency," meaning thereby the number of watts expended per candle, but how the term efficiency, as here applied, ever obtained the sanction of scientific authority is a complete puzzle to us. In scientific writing the term efficiency has uniformly the same meaning. It is a ratio, the ratio which one quantity bears to another quantity of the same character; it expresses the fraction received and utilised of the energy given to a system arranged for the transformation of energy and denotes the amount dissipated in such transformation. As applied to incandescence lamps, the term efficiency has no scientific meaning, and we are therefore glad to be able to pronounce in favour of a term which has at least the merit of consistency.

When new terms are sought to be introduced our readers should, before pronouncing a verdict, be careful to distinguish between units whose adoption would be advantageous and helpful and those which may be regarded merely as abnormal developments of a writer's caprice. The rejection of the latter after due consideration forms no argument against the adoption of the former, and the indignant refusal of engineers to revolutionise their accumulated data of half a century in order that some fancied benefit might accrue to electricians can scarcely be regarded with seriousness as an objection to the use of Bernstein's new term.

Passing on to consider some of the points raised in Mr. Bernstein's paper, we notice that objection is taken to the use of high resistance lamps, on account of the existence of minute flaws in the fine filaments. That there are such flaws we can readily believe; that they are more hurtful in fine filament lamps than in those having coarser filaments we are also ready to admit; but it is not only the relative behaviour of different lamps which we have to consider, but the relative values of the present system of parallel working with lamps of 100 volts, and the method proposed by Mr. Bernstein of working a large number of low resistance lamps in series with a potential of 2,000 volts. Disregarding the element of danger which exists in the use of such high potentials, we see only one weak point in Bernstein's method, and that is in the cut-out. We do not say that the cut-out may not work satisfactorily, but we do say that there is too much risk in the system which admits of a number of houses being plunged in darkness consequenton the possible failure of a cut-out to act when it should. The ingenuity exhibited in the construction of the main and lamp switches is doubtless to be admired, but these appear very complicated pieces of apparatus when we consider what they have to do, and how much depends on their successful working. We are inclined to question the wisdom of adopting a system possessing inherent weaknesses of the character specified, and we think its adoption would only be permissible if the line were duplexed. In this case a double cable would run all round the circuit half the lamps in every house being lit from each. It is extremely improbable that a breakdown would occur on both lines at the same time, and with this arrangement the liability to failure is enormously reduced.

Mr. Bernstein does not give in his paper any data respecting the life of his lamps. This is unfortunate, as, from our experience, reliable data connecting the strain with the life of the lamp are exceedingly difficult to obtain. It appears that the ideas of the makers regarding the strain that ought to be put on a lamp consistent with durability have undergone lately considerable modification, for now we find that instead of increasing the strain, as was the tendency some time ago, it is being gradually diminished. One manufacturing firm informs us that lamps taking 4 watts per candle corresponding to a strain of ·25 are preferred by their customers on account of their greater durability, and that their experience leads them to recommend this strain, remarking as a matter of course that the lamps made by other makers, and having a greater strain are unreliable. By another manufacturing firm we are informed that there is an element of weakness in the filaments of high-resistance lamps which conduces to shortness of life if they are worked at a high strain. To last 1,000 hours they recommend that the strain do not exceed ·25, for with a strain of ·28 the lamp will lose fully 20 per cent. of its light in that time. The Edison-Swan Company's 16 candle-power lamp takes 0·6 ampère and 100 volts, and has therefore a strain of ·26, but it is very doubtful if with this strain it will last 1,000 hours. The low-resistance lamp exhibited by Mr. Bernstein took a current of 9·75 ampères at a potential of 7 volts to give 20 candle-power which corresponds to a strain of ·29, and here, also, great duration is extremely improbable. It is significant that in no case will makers, as far as we know, recommend lamps taking 2½ to 3 watts per candle, or strained to ·4 and ·3 respectively if duration

is to be considered. It is still more significant that in no case will they guarantee any duration whatever.

We do not say that lamps should last 1,000 hours or even 500 hours. We know that the life of the lamp is in some way related to the strain put on it, and the lamp to give maximum economy, as regards the annual cost of power and renewals, must be strained to a different degree under different circumstances. But before we can determine the strain which it is most economical to give to a lamp, and by which the total annual cost shall be a minimum, it is necessary that we have clearly established the relation between the life of a lamp and the strain to which it is subjected. Several duration tests have been made from time to time, and in investigating the subject we have been compelled to collect evidence from every available source, giving due prominence to tests of most recent date. Taking them as a mean for all kinds of lamps it appears that the figures given below represent with fair accuracy the relation between the strain and the duration—

Strain.	Duration.
·1 candle per watt	4,000 hours.
·2 „	1,000 „
·3 „	500 „
·4 „	250 „

We do not say that the figures given are absolutely correct, but we believe them to be fairly accurate. Taking them as a basis for further investigation, two problems of interest present themselves for solution. The first problem is, at what "strain" should lamps be worked to obtain minimum annual expenditure when the power is supplied by a gas engine burning London gas at 3s. per thousand cubic feet? The second problem to be solved is, what must be the strain to obtain maximum economy when the power is supplied by a factory engine, the power for the lights being so small relatively to the total power given out that the interest on the motor supplying it may be in our calculations neglected? To the solution of these two problems we shall address ourselves in a future issue, but for the present we leave the subject, our readers having now been informed of the basis on which we shall proceed.

MAGNETIC SCREENS.

THE statement often met with that masses of soft iron will screen a magnet or other body from the effects of external magnetism, says Prof. W. A. Anthony in the *Electrical World*, seems not to be well understood. The effect is best explained by studying the "lines of force" by means of which Faraday so clearly expressed the effects of the magnetic field. The directions of these lines may be well shown by sprinkling iron filings on a piece of glass laid over a magnet. The curves so obtained are represented in fig. 1.

But the intensity as well as the direction of the forces in the magnetic field may be indicated by so drawing the lines that the number passing through unit area at any place shall be equal to the intensity of the field at that place, as indicated.

Where lines are close together the force is strong; where they are far apart the force is weak. In one respect, however, this diagram, which is similar to those generally given in the text books, is faulty. No line of force really ends in the space around the magnet, but is continuous from pole to pole, and, since the lines may be considered as returning to their starting points through the bar, each is a closed curve extending from the north to the south pole through the magnetic field and back to the north pole through the magnet.

It is well known that a wire carrying an electric current exhibits magnetic force. The lines of force around such a wire are circles whose centres are on the wire, and whose planes are perpendicular to it. Let the wire be wound into a helix, and these circular lines surrounding the individual spires combine to produce lines of force exactly similar to those of a bar magnet, and the helix *is* a magnet, possessing all the properties of a magnetised bar. If a bar of soft iron be put into the helix the magnetic force is greatly increased; or, in other words, the lines of force become more numerous. This is usually explained by saying that the bar is magnetised by the current and adds its force to that of the helix. But there is another way of viewing this magnetic effect of the helix, that aids greatly in understanding certain magnetic phenomena. The tendency of the helix to develop magnetic lines may be called "magneto motive force," and compared to the E.M.F. of a voltaic cell. The material in the space within and around the helix may be considered as offering more or less resistance to the formation of magnetic lines, and the number of lines formed in any case will depend upon the relation that the magneto-motive force bears to this resistance, just as the electric current produced in a given case depends upon the relation of the E.M.F. of the generator to the resistance of the circuit. Upon this view, the increased effect when iron is placed in the helix is due to the fact that iron is a far better conductor of magnetic lines than air.

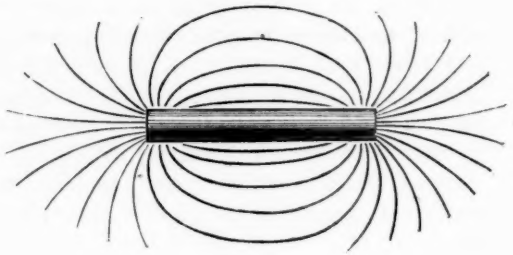

FIG. 1.

Let us apply this idea to the study of the screening effect of masses of soft iron. Suppose a soft iron ring, fig. 2, to be placed in a magnetic field. In consequence of its high conductivity the lines of force entering it on one side will follow round the ring and escape from it on the opposite side, leaving the interior almost devoid of magnetic force. But, if a plate of iron be similarly placed in a magnetic field, so far from screening the space beyond it, it will, unless it is very large, rather increase the strength of the field. Fig. 2 represents approximately the appearance of the lines of force in these two cases.

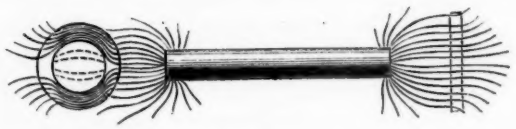

FIG. 2.

It is, therefore, not sufficient to interpose a mass of iron, unless a very large one, between a magnet and the body to be screened from its effects. To be effectual, the screen must completely surround the body, or else surround the magnet. The writer has recently tested a device for shielding watches from the effects of a magnetic field, in which this principle is applied. The shield consists of a little sheet iron pan in which the works are placed and covered with a sheet iron disc placed under the dial. It proved a perfect protection when the watch was placed edgewise within three-fourths of an inch of a large and very powerful electro-magnet. When the watch was back toward the magnet the protection was not so perfect, but was effectual in a magnetic field to which the watch would not be likely to be exposed by being worn around a dynamo.

Some familiar magnetic phenomena appear in a clearer light when the office of masses of iron is considered to be that of conductors of magnetic lines of force. For instance, when an armature is applied to a horse-shoe magnet, a good conductor of magnetic lines

is substituted for the air, a poor conductor, through which the lines, comparatively few in number, go straying round from pole to pole. The result is that, if the armature is massive enough, nearly all the lines go through it and the external field almost entirely disappears. A good analogy would be found in a voltaic battery submerged in a poorly conducting liquid. The electric current would go from pole to pole, spreading out through the liquid something as the lines of force go through the air from pole to pole of a magnet. But, if the poles of the battery be joined by a thick copper wire, the current will flow through it, and will almost disappear from the liquid. Besides this the total current is largely increased when the copper wire connects the poles, and in like manner the magnetic lines are increased when iron is substituted for air in the magnetic circuit.

In the dynamo machine it is the office of the field-magnets to develop a field in which the armature is to revolve. The masses of iron in the field-magnets and armature should be so proportioned and so placed, that the lines of force going from pole to pole shall, as far as possible, go through the armature, and not through the air outside. Magnetism outside the machine is magnetism wasted, and any considerable outside field is evidence of faulty construction. Such a defect is often due to too little iron in the armature, or too small or too long a connecting piece between the parts of the field-magnet, or sharp points or angles about the pole pieces.

PROF. HUGHES AND SELF-INDUCTION.*

CRITICAL REMARKS ON THE DISCOVERIES OF MR. HUGHES REGARDING SELF-INDUCTION IN METALLIC CONDUCTORS.

By Prof. H. F. WEBER.

PROF. D. E. HUGHES, in his inaugural address as newly-elected President of the Society of Telegraph-Engineers and Electricians (January 28th, 1886), gave a detailed account of a series of investigations, with which he has lately been occupied, concerning the influence of the nature and the form of metallic conductors upon their self-induction.†

The said investigations led Mr. Hughes to new and most remarkable results, which must needs excite considerable interest in the world of science; for, supposing these results to be indeed reliable, they would be at variance with the electro-dynamical theories of the present day, and would necessitate a thorough reform of the last.

It suffices to consider but two of the results of Mr. Hughes's researches, which must, without doubt, be regarded by every competent reader as the most important in the whole work.

Hitherto, for non-magnetisable metallic conductors, the coefficient of self-induction has been regarded as a quantity whose value depends exclusively upon the form and the geometrical dimensions of the conductor, having absolutely no relation to the material of the same. Only for magnetisable wires electro-dynamics accepted an influence exerted by the material upon the said coefficient. These wires acquire a circular magnetisation by currents passing along their axes. This circular magnetisation produces a considerable augmentation of the coefficient of self-induction, just as an iron core of a coil produces an immense growth of the coefficient of self-induction of the latter.

Mr. Hughes has arrived at results widely differing from this. He finds the coefficient of induction of *every* metallic conductor to be dependent upon the material nature of the conductor, and *variable with the same in a most decided manner*. Mr. Hughes's measurements give us in the following numbers the relative values of the coefficient of induction of straight wires of 1 mm. diameter and 30 cm. length for the various metals :—

Soft Swedish iron	100	Copper	20
Soft puddled iron	88	Brass	13
Swedish iron not softened	55	Zinc	12
Soft cast steel	41	Lead	10
Nickel	34	German silver	7
Hardened cast steel	28	Mercury	2
Cobalt	24	Carbon	1

The relation of the coefficient of self-induction to the form and dimensions of the conductor has long since been formally developed for the general case. From the general form may be deduced that the coefficient of self-induction of a long thin straight wire with a circular constant section may be expressed by

$$Q = 2\,l \left\{ \log. \left(\frac{2\,l}{\rho} \right) - 0{\cdot}75 \right\}$$

l being the length, ρ the radius of the wire.

Should the wire be of a magnetisable material, and the growth of the magnetic moment be proportional to that of the magnetising force, then the coefficient of self-induction receives a slightly different form, namely :

$$Q = 2\,l \left\{ \log. \left(\frac{2\,l}{\rho} \right) - 0{\cdot}75 + \pi . \kappa \right\}$$

κ being the constant of magnetisation.

According to these principles the coefficient of induction of such wires of constant length diminishes logarithmically with the growing thickness of the wire.

On these relations of the induction coefficient of straight wires to the thickness of the same, Mr. Hughes has made numerous determinations. His experiments gave him the general result, that the coefficient of self-induction of thin straight metallic wires depends in such a manner upon their thickness that this quantity receives the smallest value for the thinnest wire, then, growing with the thickness, becomes for a certain diameter a maximum, falling from that point by further growth of the wire in a continuous manner. For the better comprehension of this peculiar connection between the thickness and the induction coefficient of a wire, the following table gives three examples, as was found for soft iron, copper, and brass for wire diameters of :

	mm. 0·1	mm. 0·25	mm. 1·0	mm. 2·0	mm. 3·0	mm. 4·0	mm. 5·0	mm. 6·0	mm. 7·0	mm. 8·0	mm. 9·0	mm. 10·0
Iron ...	28	80	100	93	85	72	57	47	42	38	33	30
Copper	12	14	20	23	27	28	25	22	20	18	16	11
Brass	6	8	13	20	23	25	27	27	25	22	20	16

This rise and fall of the induction coefficient with the growth of the wire thickness so unexceptionally observed, and the considerable variance of the course taken by this phenomenon from metal to metal, form other serious contradictions between the measurements of Mr. Hughes and the views hitherto in vogue in electro-dynamics.

These contradictions just pointed out demand a critical investigation of the question as to which side is at fault.

The following lines have been written with the view to explain that the causes of the said contradictions lie in an incorrect interpretation given by Mr. Hughes to his measurements and that these contradictions are perfectly annulled by a correct interpretation of the data of his experiments.

Mr. Hughes employed the Wheatstone bridge. The straight piece of wire of which the coefficient of self-induction was to be measured formed the one side of the Wheatstone quadrangle, the remaining three sides consisting of a single homogeneous thin wire of German silver, bearing at two points, C and D, sliding contacts. In the one diagonal of the quadrangle, A C, was introduced the mechanism for producing an oscillating current and a first cylindrical coil, S_1. The other diagonal, B D, was led through a telephone and a

* Communicated by the Author.

† This inaugural address is to be found *in extenso* in the ELECTRICAL REVIEW, Vol. XVIII., p. 126—130.

second, smaller cylindrical coil, S_2, concentrically placed to S_1, the axes, however, forming an angle, u, which could be enlarged or diminished at will.

In measuring the coefficient of induction of the piece of wire, A B, the contacts, C and D, were so placed and the angle, u, of the axes of the two coils chosen in such a manner, that there was silence in the telephone. *Mr. Hughes believed that the angle, v, which complements this angle, u, to 90°, to be an exact measure for the coefficient of the electromotive force of the extra current and, as such, for the coefficient of self-induction of the conductor*, A B. He therefore only measured this angle; the relative values he gives for the coefficients of self-induction of the various conductors are the values of this measured angle, v.

This assumption is, however, perfectly incorrect, as may be deduced from the following remarks.

We will suppose that the variable intensities of current in the six lines

A C A B B C A D C D and B C

are at the time t

$$i_0 \quad i_1 \quad i_2 \quad i_3 \quad i_4 \text{ and } i$$

and that the resistances and coefficients of self-induction of these six lines are

$$w_0 \quad w_1 \quad w_2 \quad w_3 \quad w_4 \text{ and } w$$

and

$$Q_0 \quad Q_1 \quad Q_2 \quad Q_3 \quad Q_4 \text{ and } Q.$$

We will call P the mutual potential of the two coils, S_1 and S_2, and assume the electromotive force, ε, which excites the oscillating current in A C to be any periodical function of the same, that is, mathematically expressed, of the form

$$\varepsilon = \sum_1^m \varepsilon_h \cdot \cos.\,(h\,n\,t + \omega_h)$$

h being any integer number $1, 2 \ldots h \ldots m$, and ε_h and also ω_h being constant quantities, dependent upon the nature of the induction apparatus in use, and n standing for the value $\frac{2\pi}{T}$ (T = period of the oscillation).

If we assume further that only the two coils, S_1 and S_2, exert a mutual induction in comparison to which the effects of mutual induction between the other parts of the net of conductors may be neglected, we shall be able to arrive at the six variable intensities of current by means of the following six equations:

$$i_0 w_0 + i_1 w_1 + i_2 w_2 + Q_0 \frac{di_0}{dt} + Q_1 \frac{di_1}{dt} + Q_2 \frac{di_2}{dt} + P \frac{di}{dt} = \varepsilon$$

$$i_3 w_3 + i w - i_1 w_1 + Q_3 \frac{di_3}{dt} + Q \frac{di}{dt} - Q_1 \frac{di_1}{dt} + P \frac{di_0}{dt} = 0$$

$$i_4 w_4 - i_2 w_2 - i w + Q_4 \frac{di_4}{dt} - Q_2 \frac{di_2}{dt} - Q \frac{di}{dt} - P \frac{di_0}{dt} = 0$$

$$i_0 = i_3 + i_1 \quad | \quad i_3 = i_4 + i \quad | \quad i_0 = i_4 + i_2$$

As an expression for the intensity of the current in the bridge we find:

$$i = \sum_1^m \varepsilon_h \cdot \sqrt{\frac{\alpha_h^2 + \beta_h^2}{\gamma_h^2 + \delta_h^2}} \cdot \cos.\,(h\,n\,t + \omega_h + \psi_h)$$

in which

$$\tan.\,\psi_h = \frac{\beta_h \gamma_h - \alpha_h \delta_h}{\alpha_h \gamma_h + \beta_h \delta_h}$$

and

$$\alpha_h = w_1 w_4 - w_2 w_3 - h^2 n^2 \{ Q_1 Q_4 - Q_2 Q_3 - P (Q_1 + Q_2 + Q_3 + Q_4) \}$$

$$\beta_h^2 = h n \{ Q_1 w_4 - Q_3 w_2 + Q_4 w_1 - Q_2 w_3 - P (w_1 + w_2 + w_3 + w_4) \}$$

It is scarcely necessary to give here the long explicit forms for γ_h and δ_h, seeing they are not required in the development of the value of the coefficient of self-induction Q_1 of the conductor, A B.

The current in the bridge is constantly zero if $\sqrt{\alpha_h^2 + \beta_h^2}$ is $= 0$ for every value of h. This is not possible in general; it is, however, the case for the special conditions realised in Mr. Hughes's experiments in which Q_1, Q_2, Q_3, Q_4 and P had absolute values lying about 400 to 1,000, n running from 20π to 200π; the resistances, w_1, w_2, w_3, w_4, however, were approximately of the order 10^7 to 10^9. In consideration of this, the quantity

$$h^2 n^2 [Q_1 Q_4 - Q_2 Q_3 - P (Q_1 + Q_2 + Q_3 + Q_4)]$$

may, for Mr. Hughes's measurements, be neglected as very small compared to the products of resistances, $w_1 w_4$ and $w_2 w_3$. This is all the more allowable as the following equation of condition (2) reduces the expression

$$Q_1 Q_4 - Q_2 Q_3 - P (Q_1 + Q_2 + Q_3 + Q_4)$$

to a low value.

In Mr. Hughes's experiments, therefore, the bridge current was constantly annulled when

$$0 = w_1 w_4 - w_2 w_3 \qquad (1)$$

and

$$0 = Q_1 w_4 - Q_3 w_2 + Q_4 w_1 - Q_2 w_3 - P (w_1 + w_2 + w_3 + w_4) \qquad (2)$$

had been attained by a proper adjustment of the contacts C and D, and by a sufficient enlargement or diminishment of P by turning the interior coil, S_2, upon its axle.

These two equations render us the value of Q_1, the coefficient of self-induction of the wire, A B, in the following form:

$$Q_1 = P + \left(\frac{P}{w_4} + \frac{P}{w_3} + \frac{P}{w_2}\right) w_1 + \left(\frac{Q_3}{w_3} - \frac{Q_4}{w_4} + \frac{Q_2}{w_2}\right) w_1 \qquad (3)$$

This expression may be somewhat transformed. Supposing, firstly, the middle radius, ρ_2, of the interior coil to be considerably smaller than that of the exterior coil, ρ_1, the mutual potential, P, of the two coils may with great approximation be given by the form

$$P = 2\pi^2 \cdot n_1 \cdot n_2 \cdot \frac{\rho_2^2}{\rho_1} \cdot \sin.\, v$$

(n_1 and n_2 expressing the numbers of windings on the coils), or for small values of v by

$$P = 2\pi^2 \cdot n_1 \cdot n_2 \cdot \frac{\rho_2^2}{\rho_1} \cdot v = P_1 \cdot v,$$

in which P_1 is the short signification for the constant of the apparatus.

Further notice should be taken of the fact that in Mr. Hughes's measurements the conducting line leading from B through C and D back to A consisted in all cases of a homogeneous thin German silver wire with the same thickness.

If we call the lengths B C, C D, D A of this wire l_2, l_3, l_4 and ρ the radius of the same, we may, therefore, note the following equations:

$$w_2 : w_3 : w_4 = l_2 : l_3 : l_4,$$

and

$$Q_2 = 2 l_2 \left\{ \log.\left(\frac{2 l_2}{\rho}\right) - 0{\cdot}75 \right\}$$

$$Q_3 = 2 l_3 \left\{ \log.\left(\frac{2 l_3}{\rho}\right) - 0{\cdot}75 \right\}$$

$$Q_4 = 2 l_4 \left\{ \log.\left(\frac{2 l_4}{\rho}\right) - 0{\cdot}75 \right\}$$

These equations permit of writing the third summand on the right-hand side of equation (3), as

$$\left[\frac{Q_2}{w_2} + \frac{2 l_3}{w_3} \log.\left(\frac{l_3}{l_4}\right)\right] \cdot w_1,$$

and by introducing this in equation (3) we arrive finally at the following expression for the quantity to be determined:

$$Q_1 = P_1 \cdot v + \left\{ P_1 \cdot v \left(\frac{1}{w_4} + \frac{1}{w_3} + \frac{1}{w_2}\right) + \frac{Q_2}{w_2} + \frac{2 l_3}{w_3} \log.\left(\frac{l_3}{l_4}\right) \right\} \cdot w_1 \qquad (4)$$

This expression once given, it is easy to say what

mistake Mr. Hughes made in the interpretation he gave to the data of his measurements: *he simply assumed the coefficient of self-induction,* Q_1, *to be proportional to the angle,* v, *whereas, as lies in the nature of his method, the quantity*

$$\left[P_1 \cdot v\left(\frac{1}{w_4}+\frac{1}{w_3}+\frac{1}{w_2}\right)+\frac{Q_2}{w_2}+\frac{2\,l_3}{w_3}\log.\left(\frac{l_3}{l_4}\right)\right]\cdot w_1$$

must be added to the quantity, $P_1 \cdot v$.

This additional value, however, is proportional to the resistance, w_1, *of the conductor, of which the coefficient of self-induction is to be measured.*

This circumstance enables us at once to understand why Mr. Hughes was bound to arrive at the remarkable results we described at the beginning of this paper. From the fact of his assuming Q_1 to be simply proportional to v it followed that he constantly found a too small value for the said quantity; but the additional value varying with the size of the resistance, w_1, the mistake made was very different in different cases. In the series of observations which Mr. Hughes made to obtain the coefficients of induction of various conductors of like form and the same dimensions, but with different specific resistances, he was compelled to find those of conductors of greater specific resistance to have much lower values than those of conductors of a small specific resistance. And such was indeed the case, for Mr. Hughes gives us the relative valves of Q_1 for non-magnetisable metals as

Copper	... 20	German silver	7
Brass	... 13	Mercury	... 2
Zinc ...	... 12	Carbon	... 1
Lead ...	... 10		

It is further clear how Mr. Hughes, in examining the induction coefficient for conductors of the same metal and the same length, but of varying thicknesses, came across the remarkable rise and fall of this quantity, previously treated of and enlightened by numeric examples.

For every thickness of wire Mr. Hughes's assumption naturally gave a too small value for Q_1; but the factor w_1 of the additional term being for the same metal and for a constant length of wire inversely proportional to the square of the diameter, the fault made was for very thin wires much greater than for such of a more considerable radius. This circumstance explains qualitatively in the simplest way the rise and consequent fall of the coefficient of self-induction as determined by Mr. Hughes.

In order to obtain correct values for the induction coefficients the remainder of Mr. Hughes's measurements will have to be treated in the same manner: all the numbers given in Mr. Hughes's paper are not expressions for Q_1, but only expressions for the complex of quantities

$$Q_1 - \left\{P_1 \cdot v\left(\frac{1}{w_4}+\frac{1}{w_3}+\frac{1}{w_2}\right)+\frac{Q_2}{w_2}+\frac{2\,l_3}{w_3}\log.\left(\frac{l_3}{l_4}\right)\right\}\cdot w_1$$

or of

$$Q_1 - \left\{P_1 \cdot v\left(\frac{1}{l_4}+\frac{1}{l_3}+\frac{1}{l_2}\right)+\frac{Q_2}{l_2}+2\log.\left(\frac{l_3}{l_4}\right)\right\}\frac{w_1 \cdot q}{\omega}$$

if q and ω denote the section and specific resistance of the wire B C D A in use. This last formula makes it evident that the mistake made by Mr. Hughes would have been about a hundred times greater had he employed in his experiments in place of the German silver wire of 0·25 mm. diameter a copper wire of 1 mm. thickness. A change of wire would therefore have produced an immense difference in the whole of the results.

It may be that Mr. Hughes has noted in the register of his experiments besides the angles v all the data necessary for determining the seven values w_4, w_3, w_2, w_1, l_3, l_4 and Q_2. Should this be so, he would be able to convince himself, by introducing these values into the formula above given for the calculation of Q_1, of the facts that—

1. The coefficients of self-induction of the non-magnetisable metals are perfectly independent of their material nature, and that—

2. The coefficient of self-induction of a straight, non-magnetisable wire of circular section depends in such a manner upon the length, l, and the radius, ρ, as is expressed by the formula

$$Q_1 = 2\,l\left\{\log.\left(\frac{2\,l}{\rho}\right)-0{\cdot}75\right\}$$

That this expectation should indeed become realised I am entitled to believe by the results of some series of measurements carried out lately by myself, employing Mr. Hughes's method in determining the coefficients of self-induction of three wires, namely—

Of a copper wire of 200·0 cm. length and 0·050 cm. radius,

Of a German silver wire of 200·0 cm. length and 0·050 cm. radius,

And of a thread of mercury of 200·2 cm. length and 0·051 cm. radius.

Calculating from the data of my measurements the coefficients of induction for these conductors by means of the previously-developed formula, I was not able to discover with certainty the slightest difference between them.

All these new results, therefore, which Mr. Hughes has brought to light, must be regarded as products of an incorrect interpretation.

Electrical Laboratory of the Polytechnikum,
Zürich, *March 25th*, 1886.

ELECTRIC LOCOMOTION.

By A. RECKENZAUN.

XVI.

WERE it possible to construct electro-motors of small weight and limited dimensions, which would work efficiently at a speed of from 70 to 100 revolutions per minute, then we should get an exceedingly simple apparatus for actuating the driving axles of a vehicle. The driving axles would thus be the armature shafts, and two bearings to support the field magnets would complete the propelling mechanism. Unfortunately, it is impossible to construct motors of such small speed, giving the requisite power and efficiency, therefore it becomes a necessity to interpose between the armature spindle and the driving axle some mechanical gearing, which will give the suitable velocity ratio. If the car wheels are of a circumference which will traverse six miles in an hour when rolling at the rate of 80 revolutions per minute, and if the motor has to make 960 revolutions during the same period, then the velocity ratio is as 1 to 12. It would seem that there is nothing easier than to transmit motion at the above-named velocity ratio; numerous well known mechanical appliances will at once suggest themselves to the mind, and the only difficulty that may seem to trouble the mechanician is that of space,—the lack of space. After the question of space is settled, however, and some fruitless attempts have been made to reduce 960 revolutions of one shaft to 80 of another, then he discovers that there are few well-known elements of mechanism which will satisfy the peculiar conditions of this case. It is hard to arrange the points of merit or the conditions to be satisfied in their respective order; they all appear to be of equal consequence, and we will name them promiscuously. These are for tramcar propulsion: Efficiency, durability, simplicity, absence of noise and vibration, certainty of action, cheapness, and small weight. Protection from dirt may be obtained by careful casing in.

Countershafts, or intermediate wheels will be found requisite in almost every kind of gearing except worm gearing, there being too little room to work with one pair of wheels or pullies. Straps and pullies, with countershaft, offer all the above merits with the exception of certainty of action; straps will stretch and

also slip under certain conditions, no matter how tightly they may be placed upon the pulleys, or kept taut by means of stretching rollers; when we have to deal with sharp curves and inclines the strap and pulley mechanism cannot be relied upon; the same drawback will be found with ropes and substitutes of same. Gearing chains working in toothed wheels are more reliable, they cannot slip, and this method of transmitting motion on electric cars has been largely adopted; chains, however, cause some noise and vibration, and they require a considerable amount of attention; when once they stretch in the least degree the links will tend to ride over a tooth and cause breakage. The friction of chain gearing is by no means small, the radius of the first motion wheel which is attached to the motor spindle is necessarily very limited, therefore the twisting moment variable and the motion somewhat irregular, nor does the bending and unbending of the link joints reduce the efficiency so much as the centrifugal force tending to throw the heavy chain tangentially off the wheel; the cost of carefully constructed chains and wheels is considerable. For a study of this subject the researches of Professor Keller ("Zeitschrift des Oesterreichischen Ingenieur Vereins, 1878") will be found highly interesting; the best proportions of links and the most efficient forms of teeth for chain gearing are given in that communication.

Toothed wheel gearing, for the first motion couple, at any rate, has been abandoned by all who ever attempted to use it for high-speed machinery; the noise and wear and tear is excessive, therefore out of the question for tramcar propulsion; even with the second motion shaft it is doubtful whether the noise and vibration will not be considered too great for the comfort of persons inside and outside a vehicle. The most careful design, perfect tooling, and special materials are of no avail in pinions of small diameter running at more than 800 revolutions a minute.

Friction gear offers the advantage of simplicity, noiselessness, and efficiency, but with regard to certainty of action and durability, it occupies not the first rank. It is difficult to transmit much power through friction rollers without slipping. Although friction gear has been most successfully applied to the driving of dynamo machines (by Messrs. Siemens and Mr. Raworth), where the flywheel of the steam engine turns the pulley of the dynamo, a moderate amount of pressure between the two insuring perfect uniformity of motion, yet when the order of things was reversed, and the dynamo had to drive the wheel of a locomotive, for instance, friction gear did not appear to answer so well. When driving a dynamo we start without a great load, and when once the comparatively small inertia of the armature is overcome, and with a constant speed afterwards, such gearing answers admirably. If, however, the small friction pulley has to drive a large wheel to which a great weight is attached then the liability to slipping comes in, and very great pressure is needed so that, with the small leverage offered by the tiny pulley on the armature shaft, the requisite starting effect may be produced.

The "nest" gearing, devised by the late Professor Jenkin for the telpher locomotive, may be considered as the most perfect frictional gear ever invented, but it does not seem to have answered the expectations of the inventor, for it has been abandoned on the telpher line at Glynde. With a pair of friction wheels, running together like a pair of rolls, the contact surfaces are so small that the pressure per unit of surface must be large, and therefore the destruction of the same rapid.

When the centre of one wheel is within the diameter of the other of a pair, then the surfaces in contact are appreciably larger, and the destructive effect of the transmission of motion by frictional adhesion becomes correspondingly smaller; thus Professor Jenkin placed several rollers within the driven wheel or ring, and thereby multiplied the surfaces of contact. The results of continued work with this kind of gearing have not been published, and we are unable to judge of the practical merits of this invention.

There is another kind of friction gearing, often called "wedge gearing," which has found many applications for hoists; the circumferences of the wheels in this have wedge-shaped projections, formed by circumferential grooves, so that the projecting rings of one wheel fit into the grooves of the other, whereby motion can be transmitted with a moderate pressure. As in the former case, the contact surfaces are small, and at high velocities the wear is considerable; the coefficient of friction has to be kept at a high point for the purpose of adhesion, consequently the efficiency is rather low. The efficiency of the system will vary with the coefficient of friction and the pressure between the wheels; and if we wish to transmit much power, both these factors will have to be appreciable quantities. Writing a for the angle of the wedge-shaped contact rings, R the pressure, μ the coefficient of friction, we obtain the efficiency

$$\eta = \frac{\mu \, R}{\sin. \frac{a}{2} + \mu \cos. \frac{a}{2}}$$

if a is 30°, as would be the case according to the assumed best form, then the efficiency with ·2 for a coefficient of friction

$$\eta = \frac{\cdot 2 \, R}{\sin. 15° + \cdot 2 \cos. 15°} = \cdot 43 \, R.$$

Worm gearing has been much abused, and comparatively little attention has been given to the study and construction of this mechanism. With a rational design, excellent workmanship, careful selection of materials, and, above all, perfect lubrication, the efficiency of worm gearing can be rendered double that usually assigned to it by writers of old-fashioned text-books. Thanks to the researches of Prof. Thurston, Prof. Kimball, Mr. Beauchamp Tower, Prof. Hele Shaw, and others, the laws of friction have been entirely remodelled, in fact, all the long-established laws have been completely upset. Mr. Tower has most conclusively demonstrated that the coefficient of friction for lubricated bearings is not ·1 to ·2, as so frequently stated in text-books, but ·003 and less, and that even with moderately bad lubrication the coefficient could not be increased to much above $\frac{1}{100}$. In order that worm gearing may work efficiently, the thrust bearing must be thoroughly lubricated, and the worm, or the worm wheel, run in an oil bath, dirt being excluded by a protecting casing. Clean and well-fitting bearing surfaces, together with multiple threads, so as to render the angle of the teeth proportionately large, will furnish a durable, efficient, reliable and silent mode of transmission, such as we require for tramcar propulsion. The efficiency of worm and wheel is given by the following formulæ, where θ is the angle of the worm thread, μ the coefficient of friction, r the radius of the worm, and p the axial pitch of the worm, ϕ the angle of repose of metal on metal, then the efficiency of the pair is

$$\eta = \frac{\cot. \theta}{\cot. (\theta - \phi)} = \frac{1 - \mu \frac{p}{2 \pi r}}{1 + \mu \frac{2 \pi r}{p}}$$

Taking $\mu = \cdot 15$ as usually given in text-books; p, for example, $1\frac{3}{8}$ inches and r $1\frac{3}{4}$ inches, then the efficiency would be 44·6 per cent. only; whereas with a coefficient of friction of ·015, the efficiency comes out as 89 per cent. The results of the author's experiments point to an efficiency of about 85 per cent. at the normal working speed; at higher velocities it is greater, at low velocities less, the coefficient of friction varying with the speed. Much might be said on the subject of friction at high velocities, but not without drifting far beyond the sphere of these essays on Electric Locomotion.

The Coefficient of Friction.—In support of Mr. Reckenzaun's statement regarding the coefficient of friction varying with the speed, we may mention that the late Sir Charles Wheatstone many years ago constructed an apparatus specially to prove this fact.

MINIMUM WASTE AND MAXIMUM ECONOMY.

By Profs. W. E. AYRTON, F.R.S., and JOHN PERRY, F.R.S.

WE are all of us much indebted to Sir William Thomson for his remarkable paper given at the meeting of the British Association in 1881, since it possessed a double value. First it directed the attention of electrical engineers to the importance of determining the conditions of maximum economy when we had a choice of expenditure in two directions of such a nature that increasing the one expenditure diminished the other, for example, it was this paper of Sir William Thomson's that suggested to us the method that we published about a year ago for determining what was the most economical potential difference to use with a certain type of incandescent lamps. Secondly, this paper of Sir William Thomson's showed people how to determine the most economical gauge to give to a wire when we knew the current, the yearly value of a horse-power, the value of copper and the rate of interest on money. But what we have desired to point out in our paper on "Economy in Electrical Conductors," recently published in the ELECTRICAL REVIEW, is that, although his rule is perfectly correct mathematically, it cannot generally be used to determine the conditions of maximum economy, because some electrical condition, either in addition to the strength of the current, or in place of the strength of the current, is given us. Indeed, in the application made by Sir William Thomson of his own rule in his inaugural address he *starts* by assuming that we know the potential difference at the dynamo end of the line, which he takes as 80,000 volts. He next says let us employ a solid copper wire half-an-inch in diameter, &c.

To obtain the most economical current he uses his rule

$$C = \frac{t}{r},$$

and as 48·85 is the value he takes for t, and 0·2035 ohms the value he takes for r, the resistance per mile of his conductor, half-an-inch in diameter, he concludes that the proper value to give to C is 240 ampères.

But we deferentially submit that this is incorrect, because, as we pointed out, his rule has been obtained by finding the value of r that makes the total waste per mile

$$C^2 r + \frac{t^2}{r}$$

a minimum when C is constant and r a variable, and it cannot, therefore, be used to find the value of C when r is fixed and C is the variable, which are the conditions of Sir William's Niagara problem as he has stated it. In fact, if we regard r as constant, and C as the variable, the value of C that makes the expression for the total waste per mile a minimum, is C equal to nought. And it is perfectly true that C equal to nought leads, in this case, *to minimum waste, but not, of course, to maximum economy.* In fact, when C alone is the variable a consideration of the waste does not lead to a practicable answer, and, consequently, with the conditions that Sir William Thomson has taken with the Niagara problem a method of procedure different from the one that he has adopted must be followed in order to determine the value of C that should be used to obtain maximum economy.

In the problem solved in our paper we have considered that the power given out at the other end of the line was fixed, but as this is not one of the conditions of the Niagara problem the method followed in this paper cannot be employed either in this case. Probably the simplest way of attacking the Niagara problem is to determine the value of C that makes the *efficiency a maximum.* This may be done as follows :—

If V is the potential difference at the dynamo, n the length of the line in miles, then the power in watts received at the far end is

$$C\,(V - C\,n\,r),$$

and the power put into the line in watts equals

$$C\,V + n\,\frac{t^2}{r},$$

the second term in this latter expression representing the power used in the form of interest on the capital that has been expended on the conductor. Hence the efficiency equals

$$\frac{C\,(V - C\,n\,r)}{C\,V + n\,\frac{t^2}{r}}.$$

Differentiating with respect to C and equating to nought we find that

$$C = \frac{t}{r} \cdot \frac{\sqrt{n^2\,t^2 + V^2} - n\,t}{V}$$

makes the efficiency a maximum.

Hence we see that $\frac{t}{r}$, as given by Sir William Thomson, must be multiplied by the factor

$$\frac{\sqrt{n^2\,t^2 + V^2} - n\,t}{V},$$

a factor depending on the length of the line, and on the potential difference at the dynamo, in order to obtain the proper value of C.

For V equal to 80,000 volts, and n equal to 300 miles this factor becomes

0·8333,

hence we submit that with the 300 miles of copper conductor half an inch in diameter the proper current to employ with the particular number of hours of working, the cost of copper, the rate of interest on money, and the yearly value of a horse-power at Niagara taken by Sir W. Thomson is not 240 ampères, as stated by him in his inaugural address, but

240 × 0·8333, or 200 ampères,

in order to obtain maximum efficiency.

AN ELECTRICALLY PROPELLED SUBMARINE BOAT.

ELECTRIC launches have been successfully worked in this country for nearly four years past, and we have had records from time to time concerning this interesting and important development of electric locomotion. There are several of these launches of various sizes in England, all of which appear to have given great satisfaction. Their utility has been so fully demonstrated, that we have had hopes of seeing electricity applied to the propulsion of submarine boats; this hope seems now to be realised, and we are pleased to reproduce a paragraph from a local newspaper which gives an account of such a vessel—the first in this country—devised by Mr. J. Waddington of Birkenhead. Electricity from storage batteries appears to be far more convenient and safe than steam for such a purpose, and we feel certain that Mr. Nordenfeldt will adopt this mode of propulsion in his successful submarine vessel; we have, however, great doubts about the statement in the paper referred to, viz., that with 50 cells Mr. Waddington's boat can be driven at a speed of nine miles an hour for ten hours, and that at a slow speed it can run for about 250 miles without recharging. We should be glad to hear that this can be done, although the figures given are greatly at variance with our experience concerning the possibilities of existing appliances.

The following is the cutting which forms the basis of the above comments :—

An electrical submarine vessel has recently been tried at Liverpool with complete success. The vessel, which is cylindrical in shape, is about 37 feet long overall, 6 feet diameter amidships, tapering to a point at each end. A conning tower is placed on the top of the vessel, in the sides of which are ports which enable the

steersman to see in every direction, and which is covered by a strong watertight scuttle for access to the interior of the boat. The depth of the vessel below the surface of the water is regulated by two inclined planes, one on each side, worked by a lever amidships; and in addition there is a rudder aft, worked by a self-acting arrangement for keeping the vessel always in a horizontal position. The interior fittings are so arranged that the boat may be worked by one man, but the usual crew would be two men. At each end of the boat is a compartment for the storage of compressed air, which can be used when the boat is kept below water for a lengthened period. At the same time, owing to the absence of boiler, fire, &c., there is sufficient air space for two men to remain below water for six hours without drawing on the storage. The motive power, electricity, is stored in fifty large accumulator cells, which, when charged, are capable of driving the boat at the speed of about nine miles an hour for ten hours, either at or beneath the surface of the water, or at slow speed will drive her for about 250 miles without recharging. The motor drives the screw direct at about 800 revolutions per minute. This motor can also be coupled direct to a centrifugal pump, which, in a few minutes, empties the water ballast tanks which are used to submerge the vessel. The interior is lighted by incandescent lamps, in addition to which there is a powerful electric search lamp on the conning tower, which enables the steerman to see below water as well as above. This is the most powerful installation of electrical power ever fitted to any boat, and has been most successfully carried out by Messrs. Perry and Cox, of Liverpool. The storage cells being supplied by the Electrical Power Storage Company, London. One of the chief advantages claimed by the inventor is that a boat of this description can be carried on the davits of any man-of-war, and the cells charged from the dynamos whilst hanging on the davits. She is thus ready for use at once. A further trial of this interesting vessel was made in Liverpool in the presence of inspectors from the Admiralty on Wednesday the 31st ult., and proved most successful. The Admiralty inspectors expressed themselves highly satisfied with the results.

THE STRANGE HISTORY OF A DYNAMO,

As told by itself to

A. DYNAMICABLE.

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WHERE is the man, electrician, engineer, pure scientist or simple layman, who, if he has passed the meridian of life, has not in moments of reflection been struck with amazement by the contrast between the limited stock of information at command in the days of his youth and the extensive knowledge now prevalent regarding the practical applications of the still mysterious phenomena of electricity? In no age has science—and collaterally, it is pleasant to remark, the popular interest in scientific subjects—made such distinguishable advances as in that in which we live. What are now well-defined and settled laws were half-a-century back but the conjectural and timidly-advanced speculations of a few earnest philosophers, who ardently hoped, but scarcely dared express an assured belief, that they were in the path of true knowledge. Likewise, in the applications of abstract theories to material forms, what were a generation or so ago crude and apparently useless laboratory and lecture-room playthings have developed with astounding rapidity into the beautiful and wonder-working paraphernalia upon which the enlightened engineer of to-day relies for the accomplishment of his most ambitious designs.

Undoubtedly it is in the domain of electricity that Nature has latterly been most abundant in her revelations to mankind, and the devotee of that grand branch of physical science, if he be humble and true, feels the heart within him leap with exultant joy as he surveys the products of the genius of those inventive and intellectual giants, Arago, Ampère, Faraday, Wheatstone, Siemens, Thomson—surveys what these have done and reflects upon the glorious possibilities of the future, in the realisation of which he would fain bear a part.

"Hope springs eternal in the human breast;"

and it is this bright beacon-star which guides ever onward the earnest, but often weary searcher after truth—the hope of living not in vain, of ending this pilgrimage on earth with the solacing knowledge that something worth the doing has been accomplished and the world thereby left the richer. Certain names in every generation shine brilliantly forth and attract to themselves the admiration and the reverence of the multitude; but besides these there are hundreds upon hundreds of others, equally devoted, some perhaps equally able, lacking only opportunities for the display of their wealth of knowledge, who work and work on, unheard of except in a limited circle, never meeting with the recognition which is their due from the great world outside. Yet to the labours, incessant though unseen, of these noble men must be attributed that steady, irresistible forward march of civilisation, of culture, religion, science, everything, in fact, which is great and good, of which we are the privileged witnesses. It is because of the perfection of its minutest details that the huge machine works perfectly; it is the unremitting zeal, the ever-vigilant care of the thousand-and-one silent workers whose names are never known that give point and substantiality to the progress of the age. While honour and awe and undying fame are accorded to those who rise to sublime pre-eminence and are seen of all men, let us not forget to invoke blessings upon the heads of their less favoured contemporaries, followers—ay, brethren. One often wonders, do the masses ever dream of the infinite labour, the matchless skill, the indomitable determination which these ever-busy minds bestow upon their engrossing endeavours to coax from coy Nature her cherished secrets? It is the mission of the great ones of the earth to speak to the people of the wonders which would else remain hidden from the public gaze and incalculably less useful; but in the result are they not regarded as men who are inspired, upon whom the divine afflatus has descended with dazzling suddenness, imparting more than human power to discern, construct, and display? Are not the ignorant like men in the city street who pass by and heed not the stately edifice rising stone by stone behind the high and ugly hoarding, and are ready to attribute its appearance to a miracle when suddenly it stands forth in the fulness of its architectural glory, bereft of all that previously dwarfed or hid its beauties? When the patient toil of many heads and many hands through long, long years of alternate hope and despair at length reaches its climax in the perfected presentment of a magnificent work, as complicated as beautiful, and rich in possibilities of usefulness to mankind, do not the vulgar too often regard this thing of beauty merely as the latest "seven days' wonder," the inspired conception of a night and the work of a day?

But enlightenment is spreading fast; and who dares attempt to stay its progress? Let us rather each and every one put our hands to the plough, and push sturdily onward in the endeavour to lift our less privileged brethren from the slough of ignorance and indifference into which the force of circumstances has thrown them! Let us no longer be the selfish and exclusive beings we have been so long; let us take these works of skill and art and display them to the uninitiated—explain them wheel by wheel, plate by plate, and coil by coil, until we see the dawning of an appreciation of their beauty and their worth!

Ruminating in some such vein as this, I sauntered one sultry July day in 1885 from court to court of the Exhibition of Inventions which that year attracted me and millions more to South Kensington.

An engineer by profession, at heart a disciple of Faraday, Wheatstone and Siemens, and at the same time an ardent admirer of Swedenborg, that extraordinary being in whom were combined the rarest scientific genius and the less rare but, in this instance, equally marvellous traits of the visionary religionist—little wonder that the things I that day saw enslaved both my mind and my imagination. Hour after hour I spent in this department and that, examining minutely the objects most closely allied with my own pursuits, regarding more generally, but with not less admiration, the skilful productions of brains and hands which plot and fashion in fields widely different. I had entered the building amongst the earliest visitors,

and from the moment my gaze lighted upon the first piece of mechanism within sight no thought of time or space intruded until I had made the complete round of the exhibition. By this time it was noon; but feeling no need of refreshment, I resolved to indulge myself with a more prolonged inspection of those objects which had particularly struck my attention.

I was alone; nor did I desire a companion. Was I not surrounded by the essence of the Great of past ages—nobler company than aught having the living human form could supply? The genius of a thousand generations was incorporated in the grand achievements which greeted my vision on every side, and the exalted minds of philosophers who had passed from existence centuries before seemed spiritually present to me as I regarded the rich fruits of their almost forgotten labours. I took little heed of the swaying multitudes, except occasionally to wonder if *they* divined of aught beneath the surface of appearances, or if they attributed to the thought of *one* man the existence of each marvel upon which they bestowed a moment's curious glance; and they, in return, left me undisturbed in the full enjoyment of my almost ecstatic reveries, which seemed momentarily to transport me from the realm of things material to a spirit world, where I revelled in the fancied companionship of the greatest masters of science and of philosophy whom the ages have produced.

In this state of mental exaltation my wanderings hither and thither brought me in the course of time to an annexe wherein was gathered a vast aggregation of engines and dynamo-machinery, serving both the purposes of display and use, for here was the source of that brilliant illumination which was a notable and an attractive feature of the exhibition. Now I was in my happiest element. Conscious, at length, of the need of rest, I sat down, and gave myself up entirely to the delight of untramelled fancy. I regarded with feelings of affection the various machines around me, familiar to my eyes as the forms of the members of my own family. They were not all alike, but bore to each other just such resemblance as one sees in the different children of the same parents: this bore the name of Siemens, that of Gramme, another of Edison; others there were of various nomenclature, but in all was observable the same underlying principle of action. The varying shapes and methods of arrangement were testimony to human ingenuity; but they conveyed too a pathetic story of the limitation of human knowledge. The observance of one particular natural law, or combination of laws, was imperative, in however many different guises presented. One machine exists by reason of the action of its heart and lungs and circulating vital fluid just as does every other, and one man is no more its originator than is the immediate progenitor of the last-arrived member of the human race. The child bears the father's name, and that father is regarded as the author of its being; but he is not the inventor, the originator of humanity. Though the specimen for which he is immediately responsible presents an appearance different to all surrounding specimens, the type upon which it is based existed thousands of years ago and was the work of a far mightier hand. Man in the course of ages, by reason of illumination from outside himself—from above—has improved man, sometimes in the body, sometimes in the spirit—physically, mentally and morally—but he never yet invented man. Nor did any one individual invent the dynamo machine: to one it was given to perceive the existence of a law; he proclaimed that law, and another discovered an application for it; still another improved the application, and subsequent workers added to the improvements of the last—but none invented a new law upon which an entirely new machine could be built to subserve the same end.

"True, true—true, true; very true!"

A soft murmuring voice, conveying these words to my ears, proceeded from somewhere near me; but I could see no speaker. I looked around; no one was near. Workmen were busily engaged in another part of the building—too distant for me to hear them speak; and it was not the voice of a workman.

I listened intently, and kept my eyes fixed on the spot whence had seemed to come the gently spoken words. I had not long to wait for a repetition of the strange sounds, for again came the murmuring tones:

"You surmise truly. Man was not made in a moment; nor was I."

"And who are you?" I ejaculated, in vague wonderment, eagerly scanning every visible part of a bright looking dynamo in front of me, which was running with even speed and easy motion. By degrees the notion entered my head that it was this machine which had addressed me. As I looked more closely, sparkling eyes and smiling mouth seemed to appear,—but they were not like human eyes and human mouth. The longer I gazed, the more plainly I discerned that the swiftly revolving form before me was an animated being. Half unconsciously I repeated, "Who are you?"

"What I am you may see," came the smiling rejoinder; "but all that I have been you do not know."

"Are you not a dynamo?"

"I am now called by that name; but I have borne other names in times past, and have held different forms."

"Other names, and different forms! What mean you? I desire, I pray for enlightenment."

"And it is my duty, as well as my privilege, to give to you that enlightenment, and, through you, to the world."

"Through me! enlighten the world! Oh, strange being, what would you have me do?"

"Write! and write as I tell you the story of my existence. Learn how from little things comes that which is great and mighty. Write, and tell mankind how, while it took its ease and dreamed that it knew all things, a few men laboured earnestly, and were rewarded for their labours, having confided to them great truths, and bestowed upon them the knowledge of great laws—some of the laws which regulate the universe—how these continued to labour in the light of the few truths and little knowledge vouchsafed to them alone, and how these, and those whom they instructed, wrought their ideas into forms which the world first laughed at, then regarded with curiosity, increasing to wonder and awe, and which they finally worshipped. Oh, the foolish, mad world! In its ignorance it deemed itself wise unto all knowledge; when something beyond its comprehension appeared, it was supernatural, unearthly, to be feared—and worshipped! But I speak of a past age. We are in other times now. And still a new era is dawning—knowledge is to become universal, and you and I are instruments by which knowledge is to be extended."

The tone had changed from the soft, murmuring sound which first greeted my ears into one which was sonorous and almost commanding. The form seemed to change, too, to magnify and approach nearer and still to change, until I was conscious of a tremendous presence at which I scarcely dared look. Eloquence and command were in the tones and in the attitude.

"Write!" once more came the voice; "write what I bid you set down, and when I have told you all, take and publish it to the world."

Pencil and tablets were ready to my hands, and mechanically I prepared to obey. The voice proceeded, and I wrote as it spoke:

"I am not one machine only; I am not one form; but the incarnation of many. I am the first which was made, and I am the last which left the makers' hands. But I will tell you my history from the beginning."

The Dynamo's Story.

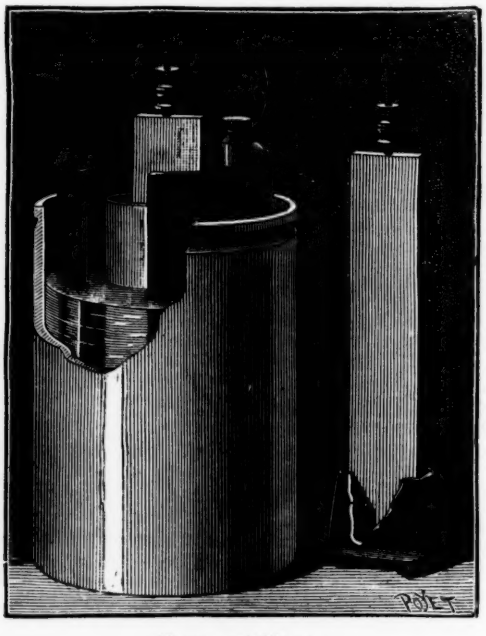
It is not by any means an easy task to relate one's own history, but as my present position in the world is now so well defined, I ask you to bear with me in my brief endeavours to make the story of my past life intelligible, hoping that some rays of light may be thrown upon that which has been, and is still

to the uninitiated, wrapped in a veil of obscurity. The technical name I bear has now become almost a household word, but about my parentage there is still some uncertainty. I must, therefore, be excused if I refrain from going too deeply into family matters, for my ancestry does not affect the present generation; suffice it to remark that I, like Topsy, "growed." Still, although my objections on this score are well founded, I may nevertheless, through you, give mankind a slight clue to my origin. My beginning, like that of the genus "homo," which, we are credibly informed, was evolved from that inanimate looking object, the jelly fish, was sufficiently primitive and crude to keep me in an embryo state for many long years, although I was ready at any moment to have assumed my present form had but the time been opportune for my entry into the world.

Till within the last decade I had somehow laboured under the impression, probably through forgetfulness of my early and incompletely imbibed knowledge, that the first discovery from which I became as it were evolved was made by one Romagnosi, an Italian. It is now, however, perfectly clear to me that the honour of the discovery of the much sought for connection between electricity and magnetism is due to the illustrious Danish Philosopher Œrsted.

This justly celebrated man, found that a closed galvanic circuit caused a magnetised needle brought within its influence to be deflected. I cannot but assume that those to whom you on my behalf will address yourself have seen and used a magnet or a magnetised needle, for these must, in the present days of enlightenment, be perfectly familar to even the youthful reader of both sexes. I will, however, at the risk of being thought dry and tedious, even at the beginning of my narrative, place before you a representation of a closed galvanic circuit. I must again assume, so as not to be thought a too garrulous specimen of my class, that you are aware that there are various sources, discovered before I was even thought of, of electrical energy.

That which will best suit the purpose I have in view is a galvanic battery, which I need scarcely remind you is usually composed of plates of different metals or plates of metal and carbon immersed in acids or



RADIGUET'S CELL.

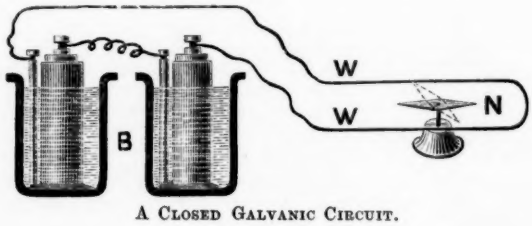
alkalis of various kinds. You think it well that I should more clearly describe one of these sources of electrical energy! Perhaps you are right, and a recent battery which has just been brought to me and which is used for producing the latest and best form of illumination—the electric light—will well answer our purpose. It is the production of one Radiguet, and it has recently undergone improvements which render it a very practical apparatus. It consists, as you see, of an outer jar of enamelled stoneware, containing an acid concentrated solution of bichromate of potash, a cylinder of carbon the head of which is paraffined, and in the middle of which is placed a porous jar the top and the bottom of which are also paraffined. This porous jar contains water acidulated with sulphuric acid in the proportion of 1 to 10. The zinc, which it also contains, is kept constantly immersed; the lower part is constantly in contact with mercury contained in a basin the outer surfaces of which are inclined. This basin is of great importance, as it enables the zinc to remain immersed without being consumed.

If the mercury is simply poured into the bottom of the porous jars, besides the fact that a great quantity is required owing to the convex form of the bottom, we observe that after some hours of working, the mercury becomes rapidly coated with sulphate of zinc, and that this scum eventually adheres to the zinc and to the mercury and completely covers the latter. At the place where the zinc and mercury are in contact, a kind of film is formed which completely prevents all contact between the zinc and the mercury and even hinders the mercury from penetrating into the pores of the zinc.

M. Radiguet's basin obviates this difficulty; the sulphate of zinc that is formed slipping over the outer surfaces, the mercury remains unaffected and in constant contact with the zinc. The acidulated water of the porous jars is changed after seven or eight hours of lighting. The same bichromate can be used for four charges of the porous jar, or for about 30 hours.

If we collect a sufficient number of cells together containing these elements and connect their poles or terminal plates by a length of wire, a chemical action is set up between the elements of which the battery is composed and that mysterious force with which we are ere long to become so familiarly acquainted is energetically produced.

In the sketch which, by the aid of your pencil I present you with, a battery or source of electrical energy, B, is joined up in a continuous circuit by a length of wire, W,



A CLOSED GALVANIC CIRCUIT.

and between the loop formed by this wire the pivoted magnetised needle, N, is placed. This will, by the action of the galvanic current, be immediately deflected or turned aside as shown by the dotted lines, and this is the important discovery which had the first bearing upon my existence.

(*To be continued.*)

SELF-INDUCTION AND INCREASE OF RESISTANCE FOR INTERMITTENT CURRENTS.

By Profs. W. E. AYRTON, F.R.S., and JOHN PERRY, F.R.S.

IN view of the able article that has recently been contributed to *La Lumière Electrique* * by Prof. Weber, of Zurich, in which the conclusion is drawn that all Prof. Hughes's new results are due to a wrong interpretation of his own experiments, it may interest your readers to see the remarks made by one of us during the recent discussion on Prof. Hughes's paper, since, although it is

* See also present issue of ELECTRICAL REVIEW.

doubtless true, as proved by Lord Rayleigh, that some portion of the results are due to the fact that effects of self-induction and of resistance are not wholly separated in Prof. Hughes's apparatus, we think it may not follow, as Prof. Weber now concludes, that there is no increase of resistance for an intermittent current. In the discussion one of us stated:—

Prof. Silvanus Thompson has referred to certain work of my colleague and myself on self-induction, and therefore I take the liberty of rising to prevent a possible misconception being produced in the minds of those who have heard Prof. Thompson speak. It is quite true, as he said, that we showed some time ago that when an intermittent current passed through a coil the effect of self-induction might in certain cases be expressed simply as an increased resistance of the coil depending on the period of the intermittency; but I think that that is not the increased resistance that Professor Hughes has brought to our notice, and I am inclined to think that perhaps the most important point in Prof. Hughes's paper has been overlooked, I think I may say, by almost every speaker except Prof. Forbes. The increased resistance which we showed an intermittent current to give to a coil was an increased resistance which, as Prof. Thompson has shown, can be arrived at by the ordinary mathematical calculations. Now the question arises, Is the *whole* of the increased resistance that Prof. Hughes has shown us to exist in a wire through which an intermittent current is flowing capable of being anticipated from the ordinary mathematical calculations? It could, of course, be obtained if one had a complete knowledge of nature; but can it be obtained from the ordinary mathematical calculations as they are given? I think the answer is, No.

We are so imbued with ordinary mathematics that somehow or other we try to explain all the results that Prof. Hughes has obtained by the ordinary laws. I am not quite in agreement with Mr. Preece when he points out that mathematics, or theory, have always been behind experiments. In many cases that criticism is unfortunately quite true; but I think Sir William Thomson's theory regarding the retardation in submarine cables was elaborated, and the laws of the proper way in which cables should be made arrived at, before the conclusions were verified experimentally. In fact, the deductions drawn by Sir William Thomson regarding the propagation of electric waves in long submarine cables by employing the system of mathematical analysis that Fourier had used in investigating the flow of heat along a bar constituted one of the most brilliant examples of theory leading practice, and made telegraphing through long submarine cables commercially possible. Without this mathematical work of Thomson's the results could only have been arrived at experimentally with the expenditure of a vast amount of money. Did time allow, it would be possible to mention many other cases where theory has been in advance of experiment.

Returning now to Professor Hughes's results, this question of increased resistance as distinct from self-induction is very, very important indeed. Mathematicians have usually assumed that in a simple circuit the growth of the current could be expressed completely if the law of variation of electromotive force were known, as well as the resistance and coefficient of self-induction. My attention was, in any marked degree, first directed to the insufficiency of the ordinary mathematical analysis in this particular by a very curious experiment that was described to me some time ago by Captain Cardew. He told me that he had found out experimentally that if the mean square of an alternating current was measured by a Siemens dynamometer, the same result was not obtained as the mean square measured by the heat of an incandescent lamp; *i.e.*, if you altered the period of alternation of your dynamo machine so as to keep the luminosity of the lamp perfectly constant, then the mean square of the current as measured by the Siemens dynamometer appeared to be different. On discussing that with my colleague, Professor Perry, he said that it probably meant want of uniformity of distribution of the current density in the wire of the dynamometer—a fact that was also referred to by Dr. Hopkinson, you may remember, at the last meeting, but I do not know whether he knew of the experiment of Captain Cardew to which I have referred. The important point to which Professor Hughes has drawn attention is, I think, that it has led us to see the important effect produced by this want of uniformity of the current density, even in a straight conductor.

Professor Thompson has just said that he could not agree with the view stated by Professor Forbes that a current on starting went one way in the middle of the wire, and the other way in the outside; and I do not myself quite agree with that way of expressing this want of uniformity in current density. No doubt, if you had what Professor Forbes assumed—a current passing down the outside, and going up on the inside—you would have a waste of power, and consequently the effect of an increased resistance. But it is not necessary to assume a flow in opposite directions to explain the phenomenon; for if you have any want of uniformity of current density in a conductor, my colleague and I have shown, in the following very simple way, that there must be an increase of resistance. For what do we mean by resistance in such a case? We mean increased heat generated per second per unit current; and it is quite easy to show that if you have a given current passing through a given wire, and if by any means you are able to destroy the uniformity of current density, then, without any current passing in the opposite direction in any part, there must be an increase in the expenditure of power—that is, an extra production of heat per second per unit current, or an increased resistance.

Let C be the total current flowing through a wire, and let c be the current per unit area at any point of the wire, so that if da be the area of a small portion of the cross section,

$$\int\int c \,.\, da = C \qquad (1)$$

Let A be the area of the cross section, then $\frac{C}{A}$ is the mean current per unit area, and

$$\int\int \frac{C}{A} \,.\, da = C \qquad (2)$$

If we consider any elementary filament of unit length of the wire, its resistance

$$\propto \frac{1}{da};$$

hence, since the current along the filament is $c \,.\, da$, the rate of generation of heat in this filament is

$$\propto (c \,.\, da)^2 \times \frac{1}{da},$$

or

$$c^2 \,.\, da$$

Hence the rate of development of heat in unit length of the whole wire is

$$= K \int\int c^2 \,.\, da,$$

where K is a constant.

On the other hand, if the current density were uniform, and equal to the mean current density, the rate of development of heat would be

$$= K \int\int \frac{C^2}{A^2} \,.\, da.$$

But the current density not being uniform, let

$$c = \frac{C}{A} + x \qquad (3)$$

where x may have any positive or negative value; then

$$\int\int c^2 \,.\, da = \int\int \frac{C^2}{A^2}\, da + 2\,\frac{C}{A}\int\int x \,.\, da + \int\int x^2 \,.\, da.$$

But

$$\int\int x \,.\, da = 0,$$

since from (1), (2), and (3)

$$\int\int c \,.\, da = \int\int \frac{C}{A}\, da,$$

and $\int\int x^2 \,.\, da$ is essentially positive. Hence

$$\int\int c^2 \,.\, da > \int\int \frac{C^2}{A^2}\, da;$$

or the rate of production of heat when the current-density is not uniform is greater than when the current-density is uniform for the same total current. That is to say, apart from what is usually understood by self-induction, there will be a seeming increase of resistance if the current-density is from any course not a uniform one. Now when a current starts or stops in a wire there must be *mutual induction* between the various streamlets of current in the wire; hence we may expect that on starting a current the current-density will be greatest near the surface of the wire and least near the centre, whereas on stopping the current it will be at the centre of the wire that the current-density will be a maximum. And since, as I have shown, any departure from a uniform current-density leads to an increase of resistance, it follows, as Professor Hughes has experimentally shown, that both on starting and on stopping a current there is an increase of resistance.

This, I think, is perhaps the most important of all the things that Professor Hughes has drawn our attention to. Some speakers at the last meeting, and others this evening, have endeavoured to explain his results somehow or other by the ordinary mathematical calculations, but I think we shall have to modify our calculations; in fact, Professor Hughes has led us to see that even in the single straight conductor it is necessary, not merely to take into account the self-induction of the conductor, but also the well-known phenomenon of *mutual induction*, which has hitherto been usually confined to the induction of one current on another. In future, it seems possible that we shall have to introduce into our mathematical expressions, in order to express the true state of nature, a term dependent on the mutual induction of the various streamlets of the current, one on the other, which has the result of producing a want of uniformity of current-density, or, more simply, has the effect of producing a real increase of the resistance, altogether distinct from self-induction, of a wire traversed by an intermmittent current.

The Legion of Honour.—Dr. Cornelius Herz, we learn, has been promoted to the rank of Grand Officier de la Legion d'Honneur.

ELECTRIC LIGHTING BILLS.

House of Lords, April 1st.

ELECTRIC LIGHTING ACT (1882) AMENDMENT (No. 3) BILL.

LORD HOUGHTON, in moving the second reading of this Bill, said that when the two previous Bills on this subject were before the House he had stated that it was the intention of the Government to bring in a Bill of their own. The Bill only consisted of one clause. By the present law the ordinary course was for a company to apply to the Board of Trade for a provisional order, which was given for a term of 21 years, at the end of which, or at the end of any subsequent period of seven years, the local authority was empowered to buy the undertaking on certain terms. The Bill enlarged the time to 30 years, and, provided the consent of the local authority was obtained, to 42 years. Then, at the end of every ten years, the purchasing powers of the local authority might be exercised. He should, however, be willing to add a clause leaving it to the discretion of the Board of Trade to increase the term to 40 years. It was the firm belief of the Government that this Bill would satisfy those who desired to promote electric light undertakings.

The Earl of CAMPERDOWN had no objection to the second reading, as no doubt some modification of the existing law was required. But the Board of Trade were thoroughly justified in taking every precaution that the public should not be exposed to losses in respect of electric lighting similar to those which they had incurred with respect to gas and water. The compensation to be given to companies at the end of the terms should be of a fixed amount.

Lord RAYLEIGH had no objection to the second reading, as the Bill was some improvement on the existing law. But no mere extension of time would meet the requirements of the case if the very stringent terms of purchase now imposed were not modified, and if no compensation were to be allowed in respect of goodwill or profit. During the last years of the term the enterprise would suffer greatly from the difficulty of carrying out improvements and maintaining the plant in order.

The Bill was read a second time.

ELECTRIC LIGHTING ACT (1882) AMENDMENT (Nos. 1, 2 AND 3) BILLS.

Viscount BURY, in rising to move that these three Bills be referred to a Select Committee, said that the Act of 1882 had been found to be insufficient. But no mere extension of time would be sufficient. The best course would clearly be to refer the three Bills to a Select Committee. He belonged to a society which comprised distinguished men of science like Sir W. Thomson and men who were acquainted with the practical application of science like Mr. Preece, of the Post Office, and which might, in distinction from the purely scientific and commercial aspects of the question, be fairly said to represent educated public opinion on the subject. It was most important that the evidence of such persons should be taken, and clearly the best way of dealing with the question was to refer the three Bills to a Select Committee. He thought that the Bill which he had the honour to introduce dealt with the subject in a much simpler manner. It provided that electricity should be supplied by meter, and that the company should not interfere with the manner in which the user of electricity chose to use the electric energy placed at his disposal. There was hardly any limit, he might observe, to the ways in which electricity might be used, and more than one meter had been found which was accepted by electricians as efficient. These were matters, however, for expert evidence, and they could be discussed far better before a committee than by talking about a Bill over their lordships' table. This was one reason why he thought all these Bills should be referred to a Select Committee. If his noble friend's Bill as it stood became law it would be impossible to get capitalists to embark a sufficient amount of money in the undertaking with any fair prospect of success. His noble friend opposite stated that there were some purveyors of electricity who were willing to come under the terms of his Bill. It might be so, but he would venture to express his belief that the terms would not be sufficiently attractive. His own Bill differed in one respect from that of his noble friend behind him, who proposed that electricity should be put upon the same footing as gas, and that there should be no fixed date at which the concerns should be handed over to the local authority, but that, like gas companies, they should be perpetual, and that only their dividends should be restricted. His scheme was that at the end of 40 years the local authorities should, if they so desired, have a power of coming in and buying the concern at a fair price as a going concern. He concluded by moving that the three Bills be referred to a Select Committee.

Lord GRIMTHORPE said that the question seemed to be whether municipal bodies were to be authorised at the end of some period which was uncertain to buy the undertakings of electric light companies for something less than they were worth. Was the corporation of any town to be allowed to buy a going concern for something less than it was worth from those who had had the risk of starting it and keeping it going? In support of that proposition he had heard nothing except that the corporations would like it. It was entirely uncertain whether electric lighting companies would be financially successful or not, but although their success was so uncertain, the House was nevertheless asked to give corporations the opportunity of playing the game of "heads I win, tails you lose" with them. If the companies paid and became prosperous the corporations would buy them; if not they would leave them alone. He would admit that the companies ought not to receive the extra price allowed by surveyors for compulsory purchase, usually 10 to 20 per cent. But he was convinced that to give municipal bodies a right which not even the State had ever before enjoyed, would, instead of encouraging the development of the electric light, only bring into existence financially weak and incompetent companies.

Lord HOUGHTON observed that the question whether the Bills should be referred to a Select Committee rested entirely with their Lordships' House. If he were right in supposing that the Government Bill would be satisfactory to the promoters of electric light undertakings, it did not seem to him under those circumstances that there was any reason for sending it to a Select Committee. The whole of this subject was threshed out thoroughly before a Select Committee of the other House in 1882, and a most voluminous report was made. All the technical questions to which the noble viscount had referred were then thoroughly gone into, and if another Committee were appointed the same evidence would have to be taken. He did not think that the result would be to place the Committee in possession of any new scientific or commercial fact upon the subject. Moreover, to send the Bills before a Select Committee would be practically to prevent any legislation taking place before the end of next session.

Lord BRAMWELL expressed the opinion that these Bills ought to be referred to a Select Committee. He did not wish to find the least fault with those who were responsible for the original Act, by which the electric light companies were given a lease of life for 21 years. No doubt the authors of that Act were actuated by the best possible motives, and were solely desirous of guarding the public against the people who embarked their capital in these undertakings. In attempting to make a good bargain for the public in 1882 the Government offered such terms as positively no one would accept. He believed that there had been one application only—he was not quite certain that there had been even one—for a Provisional Order under the Act of 1882. That this was the case was not surprising. If at the end of 21 years the undertakers were bound to sell their property, not perhaps at the price of old iron, but for a comparatively small fraction of its cost, capitalists would not embark their money in the undertaking. It might very well be that after struggling against difficulties for many years, just as a company had overcome them and were but just beginning to be able to pay a reasonable dividend upon their shares their terms of concession would expire, and the local authority would step in, and being able to borrow money at 4 per cent., would buy them out. The proposal contained in this Bill was that the term of concession should be 30 years, or, with the consent of the local authority, 40 years.

Lord HOUGHTON said that in the event of the local authority objecting to an extension of the term the Board of Trade would be empowered to extend it to 40 years or longer with the approval of Parliament.

Lord BRAMWELL said that in 1882 the Government had only offered half the advantages to a company that they did now, but he was positively assured that even the terms now offered were so bad that even under the new Bill, as under the old Act, there would be no electric lighting. He did not think that their lordships would without further information arrive at the conclusion that 40 years was a sufficiently long term, and, therefore, without the slightest desire to oppose this Bill or to throw difficulties in the way of the Government, he begged to move that the Bill be referred to a Select Committee.

Lord RAYLEIGH pointed out that the history of the Act of 1882 showed that the original proposal of the Board of Trade was that the term should be seven years only. That term was extended to 14 years in the House of Commons and to 21 years by that House. In the circumstances, it was impossible to feel much confidence that the Board of Trade had hit the exact length of term necessary for these undertakings in the present measure. The stringency of the provisions of this Bill would probably prevent the public from obtaining the benefit of electric lighting at all.

The Earl of CAMPERDOWN thought that even a Select Committee would find it difficult to form a correct estimate of the length of the term necessary from the evidence of professional witnesses who were likely to appear upon both sides, and to give evidence opposite ways with equal positiveness.

Earl GRANVILLE remarked that the arguments which had been put forward in favour of sending this measure before a Select Committee were of a very different character. The Board of Trade were exceedingly anxious that this matter should be settled, as delay with regard to it was very injurious to the public interest. He entirely agreed that it would be an almost hopeless task for a Select Committee to attempt to settle the number of years term that would induce capitalists to invest money in these undertakings. He felt convinced that if the Bill came out of the Select Committee, and was approved by their lordships' House on the principle which had been very generally advocated that night, there was not the slightest chance of its passing through the other House of Parliament, and that the question would be indefinitely delayed. He quite admitted that it was a matter for the House itself to decide, and, as the opinion of the House seemed to be in favour of referring the Bill to a Select Committee, he could only join in the hope expressed by the noble lord who

spoke last that a conclusion might be arrived at by the Committee as soon as possible.

Viscount CRANBROOK expressed his gratification that the noble earl opposite had assented to the reference of the Bill to a Select Committee. Their lordships could have but one feeling—namely, that the question should be dealt with as speedily and at the same time as soundly as possible. What they desired was that some means should be found by which the public of this country would more largely enjoy the benefits of that invention. While full protection was secured to the public interest, they did not wish capitalists to be deterred, as they were at present, by the conditions of the existing law.

The Earl of REDESDALE suggested that the Select Committee should be a small one.

The Bill was then ordered to be referred to a Select Committee.

LEGAL.

Gilman v. the Gülcher Electric Light Company, Limited.—This was an action before Mr. Justice Grantham on Saturday last, brought to recover a sum of about £220 in respect of a balance alleged to be due to the plaintiff for services rendered to the company as a director. The defendants made a counter claim for the sum of £280, of which £100 was for calls on 100 shares standing in the register in the plaintiff's own name, and £180 on 120 shares, of which his wife was the registered holder. The plaintiff admitted his liability to pay the £100 on his own shares, but disputed the £180. It appeared that five was the appointed number of members of which the directorate was to be composed, and under the ninth of the articles of association, their remuneration was to amount to £1,500 a-year, to be divided according to the number of attendances of each director, or as the board might determine. Mr. Gilman attended the board meetings up to the end of 1883, when in consequence of the hostility between himself and the other directors he was obliged to cease attending, it being admitted that if he had persisted in doing so the only effect would have been that of preventing a meeting being held; and eventually, therefore, in 1885 he resigned his position. The defendants admitted that the plaintiff was entitled to £75, which amount, they said, was in proportion to the number of his attendances, and in accordance with article nine, but they denied that any were due to him for the period between the dates at which he actually ceased to attend and resigned, although they admitted that it was a matter of impossibility for Mr. Gilman to have attended, inasmuch as the other directors refused to sit with him, and this view his Lordship adopted. The case then resolved itself to the point as to whether or not the plaintiff was liable to pay the calls on his wife's shares, for which it was admitted that he had paid in the first instance, as also for calls made upon them subsequently. Mr. Justice Grantham said that although he did not like the decision in the Parsee case, which had been cited, yet he considered himself bound by it. He therefore gave judgment for the plaintiff for £75, and for the defendants for £100 on the counter claim, leaving a balance of £30 in their favour. Costs for defendants, and a stay of execution granted that the plaintiff might go to the Court of Appeal.

Varley's Electric Plant Debentures.—On Thursday, Vice-Chancellor Bacon was asked to appoint a receiver in an action, described in the *Financial News* as Barber *v.* Varley's Electric Plant Company, and as a debenture holder's action. The debentures became due on Wednesday, but on being presented for payment it was found there was no money, the effects of the company having been seized that day and sold to pay the salaries of the secretary and managing director. Vice-Chancellor Bacon granted a receiver. Is the Varley Electric Plant Company another name for the Varley Electric Patents Proprietory?

NOTES.

Electric Lighting in Factories.—Some time ago Messrs. Laird & Co., manufacturers, Forfar, entered into an arrangement for having the incandescent system of electric lighting thoroughly tested in their works. The trial from all points of view having proved satisfactory, an order was placed with Messrs. Henry Bennett & Co., of Glasgow, to fit up a complete installation in the calendering and finishing departments, and the work has just been successfully completed on the most approved design and construction. The dynamo used is one of Kapp's patent compound wound self-regulating machines. Between 80 and 90 lamps of 20 candle-power each are used, and are divided into three circuits. The switch board controlling these is placed above the dynamo, with a switch and safety fuse for each circuit. Each lamp is also provided with an independent safety fuse. The power for the dynamo is taken from the "Corliss" engine used for driving the calendering department. The lighting has now been in operation for several weeks, and has proved very successful in every respect.

Electric Lighting in Mines.—For some time past operations have been going on in the underground workings at Newbattle Colliery, with a view to obtaining fresh grips of the various seams of coal for which this colliery is famed. These operations, which are nearly completed, give every indication of proving successful beyond anticipation. Electric lighting and signalling apparatus have also been introduced in all the principal places in the mine.

Electric Lighting in New Orleans.—New Orleans has shown commendable enterprise in substituting the electric light for gas in illuminating its streets. The city covers a large area, and, with the exception of one section, where the contract with the gas company has still several years to run, is wholly lighted by electricity. There are two arc lighting companies in New Orleans—the Brush and the Louisiana. The latter has the contract for the street lighting, which runs for three years. It supplies 700 arc lights along the various thoroughfares. The Brush company lights the 14 different markets with 30 arc lights, and the parks with 18 arc lights. It also lights the river front for five miles, in which service 100 arc lights are employed, 250 feet apart. The latter contract is not made with the city, but with the lessees, a private company. The Brush company have just received the contract for five years, which would seem to indicate that the service has been satisfactory. The Louisiana Company has been devoting its attention almost exclusively to its big city contract, yet supplies about 200 private lights. Finding the old station at 119 and 121 Magazine Street entirely too small, it has just erected a fine, new station on the new levee. It will have a capacity for 1,500 arc lights. The company uses the Fort Wayne Jenney system, and has 50 dynamos in operation. Its repairs are done in its own shop, and its employés number about 100. The new station is expected to be ready in about two months. The Brush company is now furnishing about 600 private arc lights at prices ranging from about 40 to 60 cents a night. It also lights the Exposition with 170 lights in addition to 50 supplied to exhibitors there. This company is also arranging to go into the development of the incandescent lighting business. It is likewise about to enlarge its plant so as to supply electric power for running elevators, fans, sewing machines, &c. The company pays a regular quarterly dividend of 1½ per cent.

The Electric Lighting Act.—Messrs. R. E. Crompton & Co. have circularised "the trade" in the interests of Lord Rayleigh's Bill for the amendment of the Electric Lighting Act, asking for replies to the following questions:—(1) Has your business connected with electric lighting and electric transmission of power increased during the 18 months ending April 1st, 1886? (2) If so, what proportion of your orders has been for foreign countries and the Colonies, and what proportion for home consumption? (3) What number of hands do you consider find employment at your works, or in the pay of your agents in the United Kingdom, in the work of electric lighting and transmission of power? (4) Do you consider that the relaxation of the present legislative restrictions on house to house electric lighting would result in an increase of general business? (5) Do you think it advisable that the trade should act as a united whole to protect its interests in the Committee Rooms of the Houses of Lords and Commons by employing counsel, &c.? (6) If so, will you name the maximum amount you are prepared to give towards a guarantee fund to meet the necessary expenses?

Messrs. Crompton are actuated, no doubt, by the best

motives in taking upon themselves the initiative in this matter, but we do not anticipate that they will receive many replies to the queries they have formulated.

Domestic Electric Lighting.—The final contract for lighting by electricity the well-known residence of the Right Hon. W. H. Smith at Henley-on-Thames has now been definitely signed and settled and the order placed in the hands of Messrs. R. E. Crompton & Co., thus adding another instance of the steady progress of electric lighting in private mansions and making an addition to the large number of such contracts which Messsrs. Crompton have successfully undertaken. The specification of the above work, which is of an exceptionally binding nature, has been drawn up by Mr. Musgrave Heaphy, and this gentleman together with Mr. Massey will act on behalf of Mr. Smith. The details of the contract may be generally stated as follows :—The plant will consist of one 12 H.P. nominal compound engine fitted with automatic gear, two fly wheels being used, each driving by belting one shunt-wound Crompton machine of the size known as pattern No. VIII. The boiler, which together with the engine is being supplied by Messrs. Davey-Paxman, is also 12 H.P. nominal, of the locomotive type, with special copper fire box. The engine and boiler will be fixed on independent foundations. The rest of the plant consists of a feed water heater, an inspirator, and an electric governor together with 60 secondary batteries guaranteed to maintain 60 lamps at their nominal brightness for 10 hours, this point being specially insisted upon in Mr. Smith's behalf in order to avoid Sunday working. The mains, which are heavy enough to carry current for 300 lamps (110 volts), are laid underground from the engine room to the house, and are of extra heavy insulation. The total number of lamps at present required is 200, but everything is arranged so that if desired an addition can be made to the lamps hereafter. The fittings are, generally speaking, of a simple character wherever suitable, flexible pendants being used ; in other cases brackets or table standards are employed ; all switches and cut-outs have to be mounted on non-combustible bases, and we need hardly add, all wires have to be run in strict accordance with the rules of the Phœnix Fire Office. The contractors have to guarantee the efficient working of the installation in every respect for a period of 12 months, including the secondary batteries. The contract is to be completed by July 1st, after which date we shall hope to be able to supply some further details as to the actual working and the actual arrangement of the plant.

The Society of Arts and the Electric Lighting Bill.—A petition was presented to the House of Lords on Thursday, 25th March, on behalf of the Society of Arts, by the Duke of Abercorn, C.B., Vice-President of the Society, in which the petitioners state that they are satisfied it would be to the public advantage that the use of the electric light should be extended, since the light is free from any deleterious influences upon health or upon property, and is, for many purposes, and in comparison with certain illuminants, economical, while its employment would, by competition, tend to cheapen artificial lighting generally ; that if it is desirable to extend the use of the electric light, it is obviously necessary that it should be supplied in the same way as gas ; that at present those willing to provide the electric light, in the same manner as gas is now provided, are hindered by the existing state of the law on the subject, and that in consequence the development of electric lighting in this country has not been equal to its development in other countries where no such artificial hindrances exist ; and that the Bill (Lord Rayleigh's) now before the House provides for the application of similar clauses to any companies which may hereafter be formed to supply the electric light to the public, and thereby secures an efficient protection against the growth of a monopoly likely to be injurious to the public interests. They therefore pray that the House will take these premises into favourable consideration, and will pass the said Bill for the amendment of the Electric Lighting Act.

Electric Lighting at the Indian and Colonial Exhibition.—The electric lighting at the exhibition is under the control of a committee composed of Sir Frederick Abel, chairman ; Sir Francis Bolton, who directs the garden illuminations ; and Mr. W. H. Preece, who specially looks after the lighting of the buildings. The whole of the motive power required for the internal lighting of the exhibition buildings will be supplied under contract by Messrs. Davey, Paxman & Co., of Colchester ; the power absorbed amounts to 1,200 indicated horse-power. The principal galleries and courts will be lighted by arc lamps, of which 160 are supplied by the Anglo-American Brush Electric Light Corporation, Limited ; 140 by Messrs. R. E. Crompton and Co. ; and 100 by the Pilsen-Jöel Electric Light Company, Limited ; making 400 lamps in all, each lamp giving a light equal to at least 1,000 standard candles. The Indian Palace, the dining rooms, and the different offices in the "Old London Street" (or "The Old London World's Exchange," as it is to be called this year), as well as the Colonial and Indian tea houses, will be lighted by means of incandescent electric lamps, supplied with current by the Edison-Hopkinson dynamo machines. These machines are lent by the Edison-Swan United Electric Light Company, Limited. The Club dining rooms, over the West Arcade ; the Chinese Pavilion : the Royal Box, underneath the clock tower ; the secretarial offices, and the Subway to the South Kensington Station, will be lighted by incandescent lamps, which are fed by secondary batteries, lent by the Electrical Power Storage Company, Limited. These secondary batteries will be charged by Edison-Hopkinson dynamo machines. The electric illumination of the gardens will be effected by means of about 10,000 small glow lamps (mostly of 10 candle-power each) ; and, in addition, a number of arc lamps suspended from tall masts will be used to give a strong moon-like effect when the illuminated fountains are not playing. This installation, as well as the whole of the work connected with the fountains, which have been enlarged and altered, has been carried out by Messrs. Galloway and Sons, of Knott Mill Ironworks, Manchester.

Electric Lighting Contracts. — Messrs. B. Verity and Sons have obtained the following installations during the month of March :—The Junior Carlton Club, Pall Mall, with the whole of the machinery in duplicate, and a set of accumulators, capacity, 1,000 ampère hours ; the Alhambra Theatre, 100 lights ; and Starborough Castle, 120 lights, with a set of accumulators, capacity 500 ampère hours. The Junior Carlton Club makes the third of the London clubs entrusted to Messrs. Verity, the other two being the Constitutional and the Naval and Military.

Pamphlet on Electric Lighting.—Prefixed to their price list Messrs. Swete and Main, of the Baskerville Works, Battersea, have an exposition in popular language of the requirements and methods of electric lighting.

The Telephone in Portsmouth Dockyard.—Admiral Sir George Willes, Commander-in-Chief at Portsmouth, has abolished the semaphore on the top of Government House, and telephonic communication has been established with the dockyard semaphore in its stead.

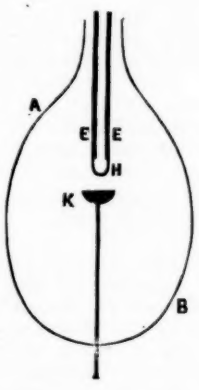
The Northern District Telephone Company.—With the advent of fine weather, and the absence of snow, work on the trunk lines in the district of this company is being pushed forward briskly. Communication between Middlesborough and Stockton was established this week, and the list of subscribers in those towns and Hartlepool is beginning to assume very important dimensions, while, as the trunk line between Hartlepool and Stockton

will be completed very shortly, and that between Sunderland and Hartlepool is progressing rapidly, all these important towns will very soon be in connection with one another. Active steps are being taken to connect the city of Durham, and a line will be run between that place and Newcastle, and an exchange opened there. Though Durham, like most cathedral cities, does not promise a large field for telephone enterprise, there being very little business done there, and people having plenty of time to walk about, and see one another, whenever such a rare thing as business requires such an unwonted exertion, yet the collieries, which are thickly scattered about the district, will probably amply repay the expense incurred in constructing the line and opening the exchange there. The large amount of business done between Newcastle and Sunderland has necessitated the addition of new wires on the trunk line, and these have been just run successfully. It is proposed to establish telephonic fire alarm stations on a novel plan at various points in Newcastle and Sunderland, and it seems quite time that this was done in all large towns.

The Bell Telephone Patent.—The American newspapers are now re-publishing from our columns the letter which Professor A. Graham Bell wrote to Attorney-General Garland, in October last, in relation to the Memphis suits to invalidate the Bell telephone patent.

Telephonic Transmitters.—We have received from America a sketch and description of a telephonic transmitter which was filed for Mr. Barney on August 16th, 1884, No. 11,364, but which he afterwards abandoned. For the benefit of our correspondent "Combination" and the public generally, Mr. Barney submits the same as being without a diaphragm, and under the circumstances, therefore, free to all. It consists of rods of carbon resting loosely in holes in carbon blocks attached to a frame. This frame, although in our opinion no more a diaphragm than the wooden frame surrounding a school boy's slate, brings the apparatus within the Edison specification, (see Mr. Justice North's recent judgment in the case of the U. T. Company *v.* Bassano), and it is therefore useless for us to do more than make a note thereon.

The Carbonisation of Iron.—In the course of a series of lectures on "Impurities in Metals," delivered at the Royal Institution, Prof. Chandler Roberts-Austen performed the experiment of turning malleable iron into steel by means of diamond dust, in such a way that it should be visible to all present. He took the glass vessel, A, B, in which descended



the battery terminal wires, E, E, connected at the ends by the loop of fine malleable iron wire, H. The little vessel, K, below contained diamond dust. The loop, H, was then made white hot by an electrical current, and brought into contact with the diamond dust, K, when it at once fused into globules, where the contact was established.

The Yacht "Kriemhilda."—Mr. A. C. Boothby informs us that this vessel, which we mentioned last week as being electrically lighted, is the property of Mr. H. A. Fergusson, the chairman of the Standard Electric Light Company.

Self Induction.—We are sure that the critical comments on the recent experiments of Prof. Hughes from the pen of Prof. H. F. Weber will be earnestly studied by our readers. This is by far the most important criticism which has yet appeared.

Electricity in the Royal Navy.—The latest addition to the elaborate electric fittings on board the torpedo ram *Polyphemus* is the electric light flashing semaphore which supersedes the Colomb flashing signals, the latter taking too long to spell messages. The electric semaphor is looked upon as a great advance, and the *Polyphemus* was consequently ordered round to Devonport from Portsmouth in order that the Signal Committee sitting at the former port might have a full opportunity of witnessing its working and putting the advantages which are claimed for it to a practical test.

Minimum Waste and Maximum Economy. — In answer to criticisms made in the discussion on Professors Ayrton and Perry's paper on "Economy in Electrical Conductors," recently read at the Society of Telegraph Engineers, they have sent us a contribution on "Minimum Waste and Maximum Economy," published in our columns this week. In this contribution they show that in many cases the most economical conditions of working cannot be arrived at by following the method originally employed by Sir William Thomson, which consisted in considering how to make the waste a minimum, and that a different method must be adopted which, in the case of long lines worked with not very high differences of potential, leads to totally different results.

Fatal Accident with an Electric Gun.—The City Coroner, on Monday, held an inquest as to the death of Mr. Charles Smith Seyton, 63, late of Preston Lodge, Walton-on-Thames, who was found shot through the heart at his office, George Yard, Lombard Street, City, on Thursday afternoon last week. The evidence showed that the deceased was an engineer, and was, in connection with Colonel Reynolds, introducing a system of electric firing of small arms, the invention of Dr. Russell, of the United States. This system was described in the REVIEW of March 26th last. A fortnight ago, in the absence of Colonel Reynolds, he read a paper upon electric firing at the United Service Institution. He was frequently experimenting with firearms in his office. On Thursday afternoon a youth named William Jackson, employed at an adjoining office, heard the report of firearms. It was followed immediately afterwards by a groan. On entering the place the youth discovered the deceased lying face downwards on the floor of his office. A doctor was sent for, but Mr. Seyton was dead. A bullet had entered the chest on the left side, passed through the heart, and lodged in the back. It was shown that the deceased, when experimenting with the firearms, several of which were found in his room, used dummy cartridges, and an opinion was expressed that by mistake he put a live cartridge in the rifle. One witness stated that he thought it was a marvel that the deceased was not shot before, as he was continually experimenting with firearms. A verdict of "Accidental death" was returned.

Gas Engine and Dynamo.—To meet the requirements of electric lighting on a small scale Messrs. Crossley Brothers, Limited, have brought out a small plant consisting of a vertical gas engine of 5 man-power combined with a dynamo, which is arranged to be driven by friction. The engine is of the vertical type, which the firm has been making for some time past, and is practically identical with the better known horizontal pattern, with the exception of such modifications as are

required by the change of form. Running at 200 revolutions per minute the engine gives 1·3 indicated horse-power and ·98 brake horse-power; at 250 revolutions it gives 1·15 brake horse-power. When running light the indicated horse-power is ·3. The dynamo is of the Jones pattern. It runs at 2000 revolutions per minute, and will feed from six to eight lamps of 20 candle-power each. It is driven by a friction pulley which runs in contact with the fly-wheel of the engine.

The Telephone and the Recent Riots.—During the recent riots in London the United Telephone Company was enabled to warn some of the banks in time for precautions to be taken by the latter.

A Telephone Contest.—A contest between two telephones was carried out at the offices of the Northern District Telephone Company, Limited, Sunderland, a few evenings ago, the types used being the "loud-speaking telephone" and the Blake transmitter and Bell Telephone Combination, the latter being supplied by the Northern District Company. The experiment, according to a local newspaper, amply demonstrated the superiority of the latter instruments over the "loud-speaking" ones, as conversations were carried on with much greater ease, and songs and recitations were heard more distinctly than was the case with the "loud-speakers." We understand that the Northern District Company is making very rapid progress, and that the Tyne and Wear will shortly be in speaking communication with Durham, Darlington, the Hartlepools, Stockton, and Middlesbrough.

The Revenue Returns.—Both the Post-office and the Telegraphs have maintained an elasticity which is remarkable alongside the evidence which other branches of revenue afford that the business of the country is non-progressive. Not only are the Post-office returns improving quarter by quarter, but the total loss to the Telegraph Revenue is but £20,000 for the entire year, notwithstanding the adoption of sixpenny telegrams, so that both these sections of the national receipts must be held to have more than fulfilled expectations.

Colonial and Indian Exhibition.—On the morning of March 29th, H.R.H. the Prince of Wales, Executive President of the Royal Commission, accompanied by H.R.H. the Duke of Connaught, a Royal Commissioner, visited the various sections of the Colonial and Indian Exhibition. Sir Dighton Probyn, Colonel Ellis, Mr. Francis Knollys, and the Hon. Major Egerton were in attendance. Sir Philip Cunliffe-Owen, the Secretary to the Royal Commission, received their Royal Highnesses, and conducted them over the buildings.

Her Majesty the Queen has been graciously pleased to intimate her intention of opening the Exhibition on Tuesday, May 4th.

The proprietors of the *European Mail* and the *Colonies and India* will publish, contemporaneously with the opening of the Colonial and Indian Exhibition in May next, a popular illustrated guide.

Charging Secondary Batteries.—A friend has asked us how Sir Thomas Bazley when charging his secondary battery, can obtain, with the dynamo running at a given speed, a rise in both E.M.F. and current. It has usually been observed that increased E.M.F. corresponds with diminished current.

Liverpool Free Public Library.—We are glad to see that the committee of this library is able to report "continued usefulness and steady progress." The annual report contains a long list of periodicals of multifarious character which are taken, and the enumeration of donations of books and other desirable acquisitions extends to gratifying length.

Electrical Conductors.—We have received specimens of electrical conductors for a variety of purposes, manufactured by the United Electric Wire Company. Leads for electric lighting is the special feature of the company's business, and arrangements are now being made for an extension of the plant for producing the same.

Protection of Submarine Cables.—The International Conference relative to the application of the treaty of March, 1884, respecting the protection of submarine cables, will, states the *Times* correspondent at Brussels, be opened at Paris on May 3rd.

Select Committee on Electric Lighting Bills.—It is proposed to refer the Electric Lighting Bills, introduced respectively by Lord Rayleigh, Viscount Bury, and the Government, to a Select Committee, composed of Earl Cowper, the Earl of Camperdown, Viscount Bury, Lord Balfour of Burleigh, Lord Rayleigh, the Earl of Crawford and Balcarres, Lord Methuen, Lord Houghton, and Lord Lingen.

Explosion of an Underground Conduit.—The iron conduit of the Sectional Underground Company, of Philadelphia, again exploded in Chicago, a short time ago, as described in the following special to the *New York Tribune*: "There was a terrific explosion of gas at Clark and Madison streets, at 1.30 p.m. to-day, and the huge iron cover of a man-hole went flying through the air twenty-five feet away. The streets were full of teams and street cars, and the side walks in all directions were crowded, and every one was badly startled. The explosion came from the underground conduit of the telegraph and telephone lines, and had been caused by escaping gas, but in just what manner is not yet ascertained. Nobody was hurt."

The Lighthouse Experiments.—Mr. C. T. D. Ackland stated in the House of Commons on Tuesday, that the cost of recent experiments at South Foreland had been about £9,000, which is to be defrayed from the Mercantile Marine Fund. Not only increased efficiency, but economy, are expected to result from the experiments.

Size for an Ocean Telephone Cable.—Prof. Chas. R. Cross, according to exchanges, has computed for the proper size of conductor for a transatlantic telephone cable. The copper conductor should be not less than 6 inches in diameter, and the insulating covering of the least electrostatic capacity should be 2 feet thick.

Lectures on Electric Lighting.—Last week Mr. A. P. Trotter lectured at Halifax on "Recent Improvements in Electric Lighting," and took occasion to attack the terminology in general use. "Electric current," he said, was more convenient than accurate, whilst "electromotive force" was altogether an abomination. The lecture proved interesting, and Mr. Trotter was rewarded by the applause of a large audience.

A lecture was given on the subject of electric lighting on Monday evening in St. Mary's Schoolroom, Isleworth, by Mr. P. J. Kelly, A.S.T.E. The experiments were numerous and successful, and the lecture was evidently appreciated by the audience. The apparatus was kindly lent for the occasion by Messrs. Woodhouse and Rawson.

The Joel Dynamo.—We recently visited Messrs. Slatter's works at Dalston, and there saw a dynamo built upon the design of Mr. H. F. Joel. The machine is of substantial construction, the axle being of steel, with phosphor bronze bearings. The armature is constructed in the special manner which we have already described in the REVIEW, namely, with detachable coils. The commutator is of an unusually large size, and the brushes and connections of the armature are very open and easily got at. It is supposed nominally to be a 6 unit machine at 850 revolutions per minute; but the inventor states that it can be made to produce 8 units. Its electrical efficiency has yet to be tested.

Cable Broken.—The submarine cable between Port Hamilton and the mainland has been broken. Our readers may remember that this cable was laid quite recently, for strategic purposes, when trouble was expected with Russia. It is to be regretted that the cable has not lasted longer.

NEW COMPANIES REGISTERED.

E. T. Syndicate, Limited.—Capital, £6,000 in 40 shares of £150 each. Objects: To acquire and work the British patents for the Immisch motor and Tatham's secondary batteries, and to carry on business as manufacturers and contractors for the supply of electric power of all kinds. Signatories (with one share each): J. Hubel, Rose Villa, Rochester Road, N.W.; R. Macpherson, Cricklewood; F. M. Jones, Perren Street, Kentish Town; E. F. Hunt, 16, Goldsmith Gardens, Acton; W. E. Slaughter, Streatham; C. T. Whinney, 21, Francis Street, W.C. The signatories are to nominate the first directors. Messrs. William David Gooch and William Lyster are appointed engineers to the company. Registered 3rd inst. by Ashurst, Morris, and Co., 6, Old Jewry.

Smith and Chamberlain, Limited.—Capital £100,000 in £10 shares. To acquire the business of Mr. Arthur Chamberlain, of Birmingham, brass founder in all branches, including the manufacture of gas, water, steam, and electric light fittings, lamps, and appliances. Signatories (with one share each): Walter Chamberlain, Harborne Hall, Stafford; Arthur Chamberlain; Miss Agnes Sloane; J. Brown; A. S. Bowler; Richard Chamberlain, M.P.; and Herbert Chamberlain, all of Birmingham. Mr. Arthur Chamberlain is appointed sole director. Registered 5th inst. by Field, Roscoe, and Co., of 36, Lincoln's Inn Fields, acting as agents for Barlow, Smith, and Pensent, of Birmingham.

Westminster Joint Stock Syndicate, Limited.—Capital £3000 in £1 shares. Objects: To subscribe or to advance money, on account of shares in companies for the construction, laying down, and working of submarine or underground telegraph or telephone cable, or other manufacture in which India rubber, gutta percha, or analogous gum is used. Signatories (with one share each): *W. Wood, 13, Delahay Street, S.W.; *Major H. Cotton, 28, Ampthill Square, N.W.; *A. H. Huth, Bolney House, Ennismore Gardens; J. Findlater, 33, Wellington Street, Strand; Surgeon-General W. Munro, 64, West Cromwell Road, S.W.; F. H. Hendre, 11, Delahay Street; T. Kent, 1, Wroughton Road, Nightingale Lane, S.W. Directing qualification, 125 shares. The subscribers to whose names an asterisk is prefixed are the first directors; remuneration, 10 per cent. of the net profits after deducting all charges. Registered 6th inst. by Walter Wood, 13, Delahay Street, Westminster.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Hirsch Greystock & Co., Limited, (Portable Electric Light Manufacturers).—An agreement dated 4th ult., and filed on the 1st inst., provides for the purchase by the company of the business of Mr. Walter Moser, of 11, Queen Victoria Street, electrician. The purchase consideration is 1,000 fully paid-up shares of £10 each.

Brighton Electric Light Company, Limited.—The statutory return of this company made up to the 29th ult., was filed on the 3rd inst. The nominal capital is £25,000 in £5 shares. The number of shares taken ud is eight of £5 fully paid, and 1,600 of £3 15s. paid, upon the latter 15s. per share has been called. The calls paid amount to £1,240. Registered Office, Gloster Road, Brighton.

Electric Locomotive and Power Company, Limited.—An extraordinary general meeting of this company was held on the 10th ult., at 6, Gt. Winchester Street, when it was resolved that the following alterations be made in the article of association. "In article 8, the words 'provided that no portion of the said capital of £50,000, exceeding £40,000 or of such increased capital shall be raised on shares issued therefor, except with the consent of all the directors, whether present at a board meeting or not, such consent to be signified by the signatures of such directors to the resolutions authorising such raising or issue as aforesaid' be cancelled. In article 9, 'and subject as aforesaid' be cancelled. That the following be substituted for article 45. 'The directors may at any time accept from any member on such terms and conditions as shall be agreed, the surrender of his shares, or any part thereof, whether fully paid or not, and any share so surrendered shall be deemed to be the property of the company, and may be disposed of for the benefit of the company in such manner as the directors may think fit.'" These resolutions were confirmed on the 27th ult., and duly registered on the 2nd inst.

Electric Manufacturing Company, Limited.—At an extraordinary meeting of the members of this company on the 22nd ult., it was proved that the company by reason of its liabilities cannot continue its business, and it was resolved to wind up voluntarily. Messrs. Hugh Erat Harrison, Hy. Newsome Myers and James Bryde McClurg were appointed liquidators. The resolution was duly filed on the 30th ult.

Varley Electric Patents Proprietory, Limited.—At an extraordinary general meeting of this company held at Park Works, Balls Pond, Islington, on the 31st ult., it was resolved to wind up voluntarily, it having been proved to the satisfaction of the meeting that the company could not by reason of its liabilities continue its business. Mr. F. H. Varley is appointed liquidator. The resolution was duly registered on the 1st inst.

Liverpool Electric Supply Company, Limited.—The annual return of this company, made up to the 29th ult., was registered on the 1st inst. The nominal capital is £200,000 in £5 shares; 2070 shares have been taken up, and £4 per share has been called thereon. The calls paid amount to £8,280, being £4,256 in excess of last year's return.

CITY NOTES, REPORTS, MEETINGS, &c.

The Indo-European Telegraph Company, Limited.

ACCORDING to the Directors' report for 1885, the company's revenue from all sources for 1885 amounted to £116,150 3s. 1d. as compared with £98,103 11s. 9d., showing an increase of £18,046 11s. 4d., or rather more than 18 per cent.

The expenses were: on commercial and general aacount, £26,509; on maintenance account, £25,088 8s. 11d., including £145 5s. 11d. paid to the Russian Government; total, £51,597 8s. 11d., as against £53,323 19s. 6d., a decrease of £1,726 10s. 7d. This is owing to the exceptional outlay on the duplicate Kertch Cable which appeared in last year's accounts. The maintenance expenditure, however, includes the cost of alterations and improvements in the company's lines. On commercial account there is an increase of £1,637 7s. 7d., mainly occasioned by staff for additional through circuits and the expenses attendant upon the increased business done.

Deducting the above expenses, taking credit for £4,578 11s. 7d. balance brought over from 1884, and debiting income tax, there remains the sum of £67,456 5s. 1d.

From this amount £10,625 has already paid for interim dividend, leaving a balance of £56,831 5s. 1d.

The Directors, after setting aside £15,000 to the reserve fund, propose the declaration of a dividend for the last six months of 17s. 6d. per share, making, with the interim dividend already paid, 6 per cent. for the year, and a bonus of 30s. per share, both free of income tax, making in all 12 per cent. for the year, and carrying forward £1,456 5s. 1d. to the credit of 1886.

The extra cable circuit by the new agreement with the Post Office, and the other additions made out of revenue to the

company's system, aided by the second wire granted by the German government, by which two special circuits are secured frome London to Teheran, continue to prove of great advantage to the working of the company's system.

The above improvements have also contributed to enable the company to deal satisfactorily with the additional business thrown upon the lines during the past year.

The large augmentation of revenue is quite exceptional and is owing to the total interruption of the Eastern Company's lines for some three weeks, the disturbances in Burmah and the Afghan Frontier question, and it is satisfactory that the £18,046 11s. 4d. of additional revenue has only occasioned an increased expenditure on commercial account of £1,637 7s. 7d.

At the Telegraph Conference of Berlin, in response to the desires expressed by the Indian Government and the German Postmaster-General, his Excellency Dr. von Stephan, it was determined to reduce the rate to India from the 1st of July next from 4s. 7d. to 4s. per word. This will cause a diminution of the company's revenue, but the Board were of opinion that the time had come for a material reduction in the tariff.

Reductions were also arranged for, to Australia and China, the amounts of which are not yet fixed, to take effect from the same date.

The Eastern Extension, Australasia and China Telegraph Company, Limited.

THE Report and accounts of the directors for the half-year ended 31st December, 1885, state that the gross receipts, inclusive of Government subsidies, have amounted during that period to £247,017 6s. 4d., against £248,087 19s. 5d. for the corresponding half-year of 1884.

The working and other expenses, including £27,236 16s. 1d. for cost of repairs to cables and expenses of ships, absorb £71,473 6s. 9d. against £79,496 9s. 1d. for the corresponding period of 1884, leaving a balance of £175,543 19s. 7d. From this is deducted £3,763 2s. for income tax, £41,595 for interest on debentures and contributions to sinking funds, leaving £130,185 17s. 7d. as the net profit for the half-year, which, with £32,858 6s. 11d. brought forward from the previous half-year, leaves a balance of £163,044 4s. 6d. Against this the balance of cost of the Singapore-Saigon and Penang-Rangoon Cable Renewals, the cost of duplicating the Victoria-Tasmania cable, and the cost of connecting and establishing a cable station at the North Saddles (China), amounting altogether to £36,076 2s. 1d., have been charged.

One quarterly interim dividend of 1¼ per cent., amounting to £31,250, has been paid for the half-year, and it is now proposed to distribute another of like amount, together with a bonus of 2s. per share payable on the 15th inst., making, with the interim dividends and bonus paid for the first half-year, a total distribution of 7 per cent. for the year 1885. The balance of £39,468 2s. 5d. has been carried to the general reserve fund, which now stands at £565,644 6s. 1d.

In pursuance of the conditions upon which the issue was made, 102 of the company's 5 per cent. debentures of 1880 were drawn by lot on the 15th ultimo for payment at par on the 1st May next.

The new cable steamer "Recorder," referred to in the last report, has arrived at her station at Singapore, and the steamship "Agnes" has left for England to be overhauled for requisite repairs. The cost of the "Recorder," amounting, with cable machinery and Electrical Apparatus to £42,606 14s. 2d., has been deducted, as shown in the balance-sheet, from the maintenance ships' reserve fund.

The cable between Victoria and Tasmania has been duplicated during the half-year under review out of the company's stock of spare cable at Singapore, and the cost (£31,190 5s.) has been charged, as above stated, against revenue.

The principal cable repairs during the half-year have been on the Java-Australian and Penang-Singapore sections, but the communication has been uninterruptedly maintained by means of the duplicate lines. All the company's cables are now in good working order.

In consequence of the frequent interruptions of late years to the Penang-Singapore (original) cable resulting in a large annual expenditure for repairs, your directors have determined to replace it with a new cable of brass-ribboned type, and a contract has been entered into with Telegraph Construction and Maintenance Company for carrying out the work. It is anticipated that a large proportion of the old line will be picked up, and after it has been overhauled and re-served will be available for extensions or renewals in other directions.

Your directors regret to report that their efforts to induce the Indian Government to lower the transit rate for international messages across India have been unsuccessful. As, however, the Australian Colonies were, at Berlin, led to expect some reduction in the cable charges, the company, after consultation with the agents-general, and notwithstanding the refusal of the Indian Government to participate in the reduction, have decided to reduce the tariff from the 1st July next by 1s. 4d. per word unconditionally, and to make a further substantial reduction provided the Colonies agree to certain conditions proposed by the company. It has also been decided to reduce the tariff between Europe and China from 8s. 4d. to 7s. 1d. per word, to take effect from the same date.

The South Australian Goverment land line between Port Darwin and Adelaide has, as usual, been well maintaned during the past half-year.

Great Northern Telegraph Company.—The accounts for 1885 show that the revenue, including £31,338 brought forward, amounted to £328,636. The total expenses were £85,136, and, provision being made for interest on and amortisation of debentures, there was a surplus of £118,436, for which an interim dividend of 5 per cent. has been paid, and an extra dividend of 3 per cent. £55,555 has been added to the reserve and renewal fund, the net amount of which is now £417,448; £2,777 has been added to the pension fund of the staff; and £29,533 has been carried forward.

Anglo-American Telegraph Company, Limited.—The Board has resolved, after placing the sum of £25,000 to the credit of the renewal fund to declare an interim dividend for the quarter ending March 31st, 1886, of 5s. per cent. on the ordinary stock and 10s. per cent. on the preferred stock, less income tax, payable on May 1st to the stockholders registered on the books of the company on March 31st, 1886.

The Direct United States Cable Company, Limited.—The Board has resolved upon the payment of an interim dividend of 3s. per share, being at the rate of 3 per cent. per annum, for the quarter ending March 31st, 1886, such dividend to be payable on and after the 24th inst.

TRAFFIC RECEIPTS.

The Cuba Submarine Telegraph Company, Limited. The number of messages passing over the lines of this company during the month of March was 3,940, estimated to produce £3,300, against 4,121 messages, producing £3,510 in the corresponding month of last year. The receipts for the month of December, estimated at £2,450, realised £2,448.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending April 2nd, were £2,482, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The Great Northern Telegraph Company, Limited. The receipts for March, 1886, were £20,000; from January 1st to March 31st, 1886, £58,680; in the corresponding month of 1885, £64,400; and of 1884, £60,600.

The Eastern Extension, Australasia and China Telegraph Company, Limited. The receipts for March amounted to £37,804, against £46,193 in the corresponding period of 1885.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of March were £1,751, against £1,467 in the corresponding period of last year.

The Eastern Telegraph Company, Limited. The receipts for March amounted to £53,016, against £68,296 for the corresponding period of 1885.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending April 2nd, amounted to £3,076

The West Coast of America Telegraph Company, Limited. The gross earnings for the month ending March 31st were £3,525.

NEW PATENTS—1886.

4491. "Incandescent electric lamps." F. SCHAEFER. Dated March 31. (*Complete.*)

4492. "Novel adjustable electric lamp." G. H. SALVAGE. Dated March 31.

4522. "Process of utilising the spent liquid from certain voltaic batteries." W. S. SQUIRE. Dated March 31.

4523. "Induction apparatus, or secondary generators." H. Müller. Dated March 31. (*Complete.*)

4533. "Electric flash signalling apparatus." E. S. BRUCE. Dated March 31.

4555. "Distribution of and apparatus for transforming continuous electrical currents." A. LE N. FOSTER, F. V. ANDERSEN. Dated April 1.

4575. "Secondary batteries." W. J. S. BARBER-STARKEY. Dated April 1.

4584. "Operating switches." C. BROWETT. Dated April 1. (*Complete.*)

4630. "Stranded electric conductors." E. W. LANCASTER. Dated April 2.

4634. "Tension regulators for telephones, &c." G. A. NUSSBAUM. Dated April 2.

4660. "Apparatus for altering the potential of electrical currents." J. D. F. ANDREWS. Dated April 2.

4662. "Automatic electrical distribution and charge of secondary batteries." F. KING. Dated April 2.

4663. "Electric generators." F. F. Stögermayr, V. GLASSNER. Dated April 2.

4751. "Application and utilisation of magnetism or electro-magnetism for the separation of metals and for other purposes and apparatus therefor." H. S. MAXIM. Dated April 5.

4755. "Switches for making or breaking electric circuits." R. CORNTHWAITE, R. INGHAM. Dated April 6.

4796. "Arc lamps." R. KENNEDY, R. DICK. Dated April 6. (*Complete.*)

4799. "Galvanic finger rings, bracelets, necklets, anklets, &c." W. SCHULLER. Dated April 6.

4809. "Electric furnaces." W. P. THOMPSON. (Partly communicated by the Cowles Electric Smelting and Aluminium Company.) Dated April 6.

4810. "Electrically controlled lock." W. P. THOMPSON. (Communicated by M. Gillet.) Dated April 6.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1885.

3115. "Improvements in the manufacture of carbon filaments for incandescence lamps." R. Dick. Dated March 10. 6d. The inventor forms carbon filaments from strands of silk, cotton, or other fibrous substances, or from strips of paper or parchment or of woven fabrics, or of other materials commonly employed for the purpose, which strands or strips he encloses within tubes of copper, or other soft and ductile metal, which afterwards draws down through dies or otherwise to reduce the diameter of the tubes and thereby to compress the materials within them. The strands or strips may either be enclosed within solid tubes, or the tubes may be formed round or partially round them out of flat or channelled strips of metal. The compressed filaments thus formed are then cut into suitable lengths, and bent or shaped to the desired form, and are carbonised in the ordinary way. After carbonisation of the filament the copper tube or other metallic coating is removed from the greater part of its length by immersion in nitric acid, or by electrolysis, or by other well-known means, the metallic coating being however left at the ends to serve as a convenient means of connecting the filament to the conducting wires of the lamp by soldering, screwing, or clamping.

3121. "Improvements in and apparatus for transmitting rotary motion to dynamo-electric machines, which improvements and apparatus are also applicable to transmitting rotary motion from electro-dynamic machines." H. Lindley. Dated March 10. 8d. The inventor mounts a disc or plate upon the axle or shaft of the steam-engine, or other motor above mentioned, and in the face of the said disc he forms grooves or slots, which grooves or slots extend across the face of such disc—the armature and other revolving parts of the dynamo-electric machine he places so that the axis thereof is parallel to the axis of the shaft or axle of the steam-engine or other motor above referred to—upon the shaft or axle of the armature and other revolving parts of the dynamo-electric machine he mounts a disc plate or arms, secured to which disc plate or arms are pins or studs, upon which pins or studs are or may be mounted bowls rollers or blocks, which pins, studs bowls, rollers or blocks pass into the grooves or slots formed in the disc or plate previously mentioned, and are acted upon by the sides of such grooves or slots.

3212. "Improvements in dynamo-electric machines and in electro-motors." G. Hookham. Dated March 12. 8d. Relates to improvements in the cylindrical armature described in specification No. 7533, 1884, having longitudinal grooves or slots in which the conductor is wound, and so arranged that the sum of the sectional areas of the ribs or ridges at one time under a pole piece of the field magnets is equal or nearly equal to the magnetic section of the rest of the armature.

3247. "Improved instruments for determining or measuring electric currents and electromotive force." O. March. Dated March 12. 6d. The primary object of the invention is to produce instruments for measuring electric currents which shall not only be direct reading, but also have a wide range of reading; be easy of calibration and inexpensive to manufacture.

CORRESPONDENCE.

Electric v. Oil Lamps.

My remarks at the Society of Arts on the above subject have been misquoted, and your correspondent, Mr. Cotterill, has been thereby misled.

What I did say was, that the comparative tables of cost given in Mr. Edwards's paper on Lighthouse Illuminants were hardly fair to the electric light, as they were made out on the supposition that an electric light of enormous C.P., 20 times as powerful as that given by the 108 ring gas burner, must be used at all times whether such an enormous light were required or not. I said that by proper arrangement an electric light could be furnished for lighthouse pnrposes which could be easily adjusted so as to give a sufficient light for ordinary clear weather, but which could be increased to any desired extent up to and even exceeding the enormous lights shown at the Foreland, and that the result of this modification would be that whereas the Lighthouse Illuminants report shows that the electric light costs two-and-a-half times as much as oil does, it need only cost one-and-a-half times as much as oil. The report on Lighthouse Illuminants to which I refer estimates the cost of an electric light station with single light having double power for fogs at £17,749, and the cost of maintenance at £1,927 per annum, whereas the corresponding figures for an ordinary first order oil lighted tower are £8,064 18s. 3d. and maintenance £724 4s. 7d. per annum. I propose to reduce the maintenance of the electric lighting station from £1,927 to £1,100. 1st. By providing for ordinary lighting in clear weather a group of 14 50-C.P. incandescent lamps and arranged in a close cylinder, and not occupying a greater space than the present Douglas 6-wick burner. For thick weather I propose to substitute a powerful direct current arc light, the full advantage of which could be best obtained by using a catoptric arrangement instead of the dioptric one hitherto employed for alternating current lamps. This catoptric arrangement would necessitate a revolving or partly revolving light, and as electricity is most likely to be used on headlands on the main land the beam need not revolve or oscillate through the entire circle. I know there is no difficulty in working out the practical details of such an arrangement as I have here briefly sketched out. The electric current for the incandescent lamps or for the large arc lamps can be supplied with the greatest certainty and steadiness from accumulators which could be charged by a comparatively small combined steam engine and boiler, or where gas works are accessible, by means of a gas engine. In this way the extremely heavy charges of £800 a-year for wages, coke, oil and carbons, as estimated in the report might be reduced fully one-half. The first cost of the plant, hence the charge for depreciation and renewals, would be greatly reduced. I will not occupy more of your valuable space by going into details. I think I have said sufficient to show that a strong case may be made out for the economy as well as the efficiency of electricity employed as a lighthouse illuminant.

R. E. Crompton.

Mansion House Buildings,
London, *April 1st*, 1886.

Proofs that Electricity is an Element.

In 1882 I published* the particulars of some experiments which led to the conclusion that electricity is a kind of matter which, although it does not gravitate, yet seems to be the medium of gravitation in common matter. I hope you will allow me to lay before your readers some facts which establish the accuracy of the foresaid conclusion.

1. Prof. Dewar has proved that oxygen gas is a transparent, colourless fluid when exposed to a temperature of — 130° C., and under a pressure of between 80 and 100 atmospheres, and also that liquid oxygen does not act on sodium, potassium, phosphorous, hydrogen, and other re-agents.

2. MM. Hautefeuille and J. Chappius proved by experiments that ozone, at the temperature of — 23° C., and under a pressure of 75 atmospheres, is a liquid of an azure blue colour.

3. All the modern books on chemistry assert that ozone is condensed oxygen.

4. Prof. Dewar found that the low temperature of — 130° C., and pressure of 80 to 100 atmospheres, was incapable of condensing oxygen into ozone. Therefore something still more powerful is required in order to condense oxygen into ozone.

5. According to all modern books on chemistry, three volumes of oxygen gas are condensed into two volumes by their conversion into ozone, namely, that "ozone is oxygen existing as a triatomic molecule." Is this the truth? Yes; but it is not the whole truth. It takes something more than oxygen to make ozone; but this something is not allowed to have an existence according to books on chemistry.

6. When a frictional electric machine is set in motion, the peculiar smell which arises is caused by the free electricity acting on the oxygen of the air, and converting it into ozone. And when scientists wish to make ozone in considerable quantity they pass

* The *Engineer*, Vol. LIII., p. 360. The *Electrician*, Vol. IX., p. 63.

oxygen gas through a tube, which is electrified positively, namely, at that which is called a high potential, and the gas which goes in at one end of this tube as oxygen comes out at the other end in the form of ozone. In other words, a supply of electricity is required to condense oxygen into ozone.

7. If ozone gas be shaken within a glass vessel containing some powdered glass, the electricity which the oxygen had absorbed to convert it into ozone leaves the ozone and goes into the powdered glass, and the ozone expands into and becomes oxygen gas. This process of making a portion of oxygen gas to alternately condense into ozone, and again expand back into oxygen, by alternately adding and subtracting the necessary quantity of electricity, may be carried on indefinitely. In other words, we can make ozone synthetically by adding an element to oxygen, and we can decompose ozone analytically by subtracting the said elements. Yet, according to all the books on chemistry hitherto published, the element in question is not granted to have any existence. It is looked upon as being merely a mathematical quantity.

8. Look, now, at the enormous difference there is between oxygen gas condensed into ozone by means of electricity, and oxygen gas converted into a liquid by the low temperature of — 130° C., and a pressure of from 80 to 100 atmospheres. The oxygen condensed by the means of adding electricity acts with enormously increased powers on all the ordinary re-agents, and it acts so powerfully on such substances as vulcanised India rubber, that if a tube of it be used to pass ozone gas through, the ozone soon destroys the tube; but oxygen alone cannot do this, and when oxygen is condensed into the liquid state by low temperature, combined with enormous pressure, it loses all its power to act on the common re-agents, on which it acted so well when in the gaseous state. Why is this? When oxygen is condensed into ozone it is by means of electricity added to it; whereas, when oxygen is converted into a liquid by low temperature and great pressure, there is good reason to believe that the amount of electricity which the oxygen held in the latent form while it was in the gaseous state is crushed out of it in order that the oxygen might go into the liquid state, and that it is the reduced quantity of electricity within the liquid oxygen which makes it incapable of acting on the common re-agents.

Although it is undoubtedly the extra amount of electricity which becomes latent within the oxygen and converts it into ozone and gives the latter its increased power of acting on reagents, yet scientists won't admit that ozone is a compound of electricity and oxygen. Their theory which asserts that electricity is a nonentity, is contradicted by the foregoing facts.

Maxwell wrote, in his "Elementary Treatise on Electricity," page 8, "The analogy between temperature and potential must not be assumed to extend to all parts of the phenomena of heat and electricity." . . . . "We must remember that temperature corresponds to a real physical state, whereas potential is a mere mathematical quantity, the value of which depends on the point of reference which we may choose. To raise a body to a high temperature may melt or volatilise it. To raise a body together with the vessel which surrounds it to a high potential produces no physical effect whatever on the body." Is this true? In order to convert oxygen into ozone, the tube through which the oxygen passes requires to be kept at a high electric potential, and it is because it is so kept that the oxygen passing through the tube absorbs electricity and the oxygen is thereby converted into ozone, which fact is the very opposite of Maxwell's statement that "a high electric potential has no physical effect on the body"—the oxygen.

Although electricity may not gravitate, yet it has the power of causing common matter, such as oxygen, to cohere and condense so that three volumes of oxygen are crushed into two volumes which we call ozone, and hence electricity must be an element.

There is another interesting matter in connection with this subject. When MM. Hautefeuille and Chappius attempted to condense ozone gas into the liquid form they found that the ozone exploded in the glass tube they were condensing it in when the temperature was allowed to rise higher than—23° C., and at the time the explosion occurred a flash of yellowish light appeared within the tube.

These scientists did not attempt to explain these phenomena, but there can be only one cause for the explosion, namely, the sudden decomposition of the ozone; its latent electricity having suddenly left it, the two volumes of ozone would instantly become three volumes of oxygen, hereby producing the explosive force. Now arises the question, What induced the latent electricity to leave the oxygen? As the rise of temperature was the primary cause of the explosion, it must have been the increased quantity of heat within the tube which attracted the latent electricity and took it away from the ozone, and if so, then we know that it must have been the union of the extra heat with the latent electricity which produced the flash of light within the tube.

James Johnstone.

8, Merchiston Park, Edinburgh,
April 2nd, 1886.

Secondary Generators or Transformers.

Although we consider the newspaper discussion in reference to Messrs. Zipernowski, Deri, and Blathy closed as far as we are concerned, we cannot allow the claims described in their letter of the 18th ult. to pass without protest, and we declare for the last time that we shall not allow anyone to employ secondary generators or transformers of any model or under any conditions for the purpose of distributing electrical energy.

L. Gaulard.
J. Dixon Gibbs.

18, Warwick Street,
Regent Street, W., *April 6th*, 1886.

[At the time the apparatus of Messrs. Gaulard and Gibbs was first exhibited at the Royal Aquarium we pointed out what previous workers had done in the direction of distributing electrical energy by means of induction coils, *alias* secondary generators, *alias* transformers. We do not think, therefore, that our correspondents quite appreciate the situation, or they would not publish such an absurdity as the threat contained in the above communication.—EDS. ELEC. REV.]

Mechanical Telephones.

A man representing himself as an agent of the Telephone Companies called on me respecting a mechanical telephone I have in my place, and threatened me with proceedings unless I removed same. Will any of your contributors inform me whether there is the least ground for any such act on the part of anyone, be he Postmaster-General, secretary of telephone company, or what not?

"Iron."

[The Telegraph Acts have been held to cover the electric telephone, and, as the wording of the clauses of those Acts does not confine their application to electrical methods, but mentions "electric or other telegraphs," and "any cables, apparatus, pneumatic or other tube, pipe, or thing whatsoever used for the purpose of transmitting telegraphic messages," we are inclined to the opinion that the Postmaster-General would claim jurisdiction over any public mechanical system. "The Telephone Companies" certainly have nothing to do with the matter, if by the phrase is meant, as we surmise, the United Telephone and its subsidiary companies. If our correspondent's telephones are only used for private purposes we see no reason for the interference of any person.—EDS. ELEC. REV.]

The Efficiency of the Edison-Hopkinson Dynamo.

I presume that Mr. Walmsley, in the letter published in your last issue regarding the recent tests made by Messrs. Mather and Platt on the efficiency of the Edison-Hopkinson dynamo, refers to the balance of loss unaccounted for after deducting the known losses in the magnets and armatures of the generator and motor respectively from the total loss as determined by the dynamometer. In the calculation published in your issue of March 5th, this was divided equally between the generator and motor, for which there is good reason, on theoretical grounds, on which I do not now propose to enter. The total amount in question is only 831 watts, out of 42,917 watts developed, and, if divided between the two machines in any other proportion, the effect would be merely to increase or diminish the efficiency of the generator by some fraction of 1·94 per cent. and to diminish or increase the efficiency of the motor in the same ratio.

Edward Hopkinson.

Salford Iron Works,
April 1st, 1886.

Secondary Batteries as Regulators.

Mr. Sellon's remarks bear out my theory, stated in other words, but his arguments apply only to special cases, and one of his conclusions is erroneous. Clearly, if the cells being fully charged, and then the lighting circuit used (no current flowing to the cells at the time), were sufficient by itself to regulate and such regulation remain with more or less lamps on, then a small accumulator would suffice for any sized installation, but such is proved by theory and practice not to be the case. Mr. Sellon's experiments appear, from his description, to have been limited to cells used with small dynamos, and probably with rapidly falling curves. I concur with all his remarks if this condition is inserted, but very different conclusions result if we go outside this.

Mr. Sellon's further remarks on the results to be expected when cells and dynamo share the work, also are only true in special cases. It is not my intention to occupy your space to explain this again, for, in my paper on "Constant E.M.F., &c.," the conditions were fully worked out for all cases.

It is as I have always maintained, regulation is usually obtained by accident, not by design.

David Salomons.

20, Hyde Park Terrace, W.
April 3rd, 1886.

Energy Meters.

With reference to the interesting article in your issue of the 2nd inst, describing Mr. Weston's new Energy Meter, which consists of an electro-motor having its field magnet wound with fine wire, and which is placed as a shunt to the circuit, the electrical energy given to which it is desired to measure, while the armature is traversed by the main current and so rotates, the number of rotations made in a given time, recorded on a counter, being a measure of the total energy as the motion of the armature is resisted by fluid friction from its dipping into a mercury trough, I may remind you that such energy meters have been made and practically used since the commencement of 1882. They are fully covered by claim No. 1 of the patent of Professor Perry and myself, No. 2642 of that year, which states—(1) "In measuring the total amount of energy given to an electrical circuit, the use of an electro-motor whose fixed and movable parts have soft iron or else non-magnetic cores wound respectively with a coil or coils of small resistance through which the main current of the circuit passes, and a coil or coils of high resistance through which passes a current proportioned to the difference of potentials at the ends of the circuit in question, the motion of the motor being resisted by vanes immersed in a fluid or by other resistance which is proportional to the velocity substantially as described."

The Clock energy meter covered by Clause 2 of the same patent, and which was described in your columns last year, in connection with the exhibits at the Inventions Exhibition, is the form that we have preferred to use on account of its greater simplicity, and is therefore probably better known.

W. E. Ayrton.

April 5th, 1886.

Compound Wound Dynamos in Parallel.

We have noticed that, in his recent work on dynamo-electric machinery, Professor Sylvanus Thompson mentions the great difficulty experienced in working compound-wound dynamos in parallel circuit, because of the fact that the slight difference in E.M.F. which is liable to exist between two or more machines will be greatly aggravated until the stronger machine short-circuits through the weaker, and the balance of the system is completely destroyed.

He also states that Mr. W. M. Mordey has pointed out "that the difficulty may be overcome by connecting the parallel machines in such a way that not only are the shunt portions of the field magnets in parallel circuit, but the series circuits of the field magnets are also a shunt on one another; in other words, by connecting the brushes as well as the terminals in parallel circuit."

We think it but just to state that this method of solving the difficulty has long been known to ourselves, and practised in connection with the Thomson incandescent dynamo, made by the Thomson-Houston Electric Company, Lynn, Mass., and that it was finally made the subject of United States patent, dated Oct. 13, 1885, to E. W. Rice, jr., a copy of which patent we enclose.

We have often noticed that the same idea frequently occurs almost simultaneously to different persons pursuing the same line of work, and the present case appears to be but one more interesting example.

E. W. Rice, jr.

Thomson-Houston Electric Company,
Lynn, Massachusetts.
March 24th, 1886.

[We have forwarded the copy of Mr. Rice's patent to Professor Silvanus Thompson for his perusal.—EDS. ELEC. REV.]

The Bassano-Slater Telephone Case.

"L'Homme Qui Rit" in his "plums" has very well put some of the extraordinary reasons given by Mr. Justice North, and which caused considerable astonishment to many who heard his Lordship deliver the same. Unquestionably it is one of the most marvellous contributions we have yet heard upon the subject, and conclusively proves the incompetence of an ordinary legal tribunal to deal with scientific questions.

Will you permit me to give "in his Lordship's own words," one or two instances with the addition of a brief comment.

Mr. Justice North says at the date of Edison's patent (July, 1877, not 1878 as "L'Homme Qui Rit" says) "no mode, by which articulate speech could be reproduced at long distances had yet been worked out."

At last we have legal authority for contending that Graham Bell was not the first inventor of the speaking telephone.

Mr. Justice North says, that according to the specification, the diaphragm or tympans might be "wholly or *partially* across the instrument." The intention in using the word *partially* is obvious to anyone knowing the defendant's transmitter. Now there is not a single instance either in the letterpress or drawings of a diaphragm "*partially*" across the instrument.

He further states that the "red back" was the acting diaphragm in the defendant's instrument, because the defendant's instrument "speaks better when the outside of the red back is addressed than when the voice enters the mouthpiece." I should have thought that the logical conclusion from this was, that when the mouth-

piece is spoken to, as must be the case in the defendant's instrument when in actual use, the red back was *not* acting as a diaphragm.

The defendants therefore infringe, not because they had a diaphragm—not because in having the red back they were utilising the function of a diaphragm; but because the red back *possessed* the function.

But further, the "tube" and the bell shaped "black base" which holds the carbon blocks and pencils are diaphragms. It matters not what is the obvious intention in their use. If they are capable of vibration they are diaphragms, according to Mr. Justice North. Their shape matters not! It is only a question of degree! It is the *function* that is the diaghragm. Edison claims the function to vibrate possessed by a diaphragm, not a diaphragm whose function is to vibrate! Could absurdity be carried further? Edison makes a most decided disclaimer of general principles or of details, other than the combination of the two details, diaphragm and tension regulator "*substantially as described.*" Separately, he is no more entitled to the diaphragm, than to the tension regulator. Therefore if he is entitled to the function of the diaphragm, he is entitled to the function of the tension regulator, that is, to vary the resistance in a closed circuit pure and simple. But unfortunately for Mr. Justice North's reasoning, Edison states himself, that he does not claim this. Still Mr. Justice North says, his diaphragms differ "in size, *principle*, material, *form*, position and *otherwise*." Can anyone suggest what description of diaphragm the *otherwise* is, and if it possesses the all important *function?*

Mr. Justice North says, the contention of the defendants could not be maintained "either upon principle or authority." As regards the principle, he says, Edison "discovered a very remarkable *new manufacture*," and indicated several *practicable modes* of carrying it into effect.

We will leave the *practical modes*, with the mere remark, that none of them has ever been in *practical* use. Further, it was not a "*new manufacture.*" It was merely an improvement. The specification itself states, that it is simply for an "*improvement* in instruments for controlling by sound the transmission of electric currents and the reproduction of corresponding sounds at a distance," and the disclaiming clause disclaims the general principle of a new manufacture, and confines itself to two details—disclaiming all others.

However, Mr. Justice North says so, and that consequently, being a *new manufacture*, he need not describe all the modes of carrying it out, therefore (now please observe his Lordship's reasoning), "if the defendants *place a diaghragm* in their apparatus, which performs the *functions* of diaphragm in the plaintiff's apparatus" they infringe, &c.

It is a reversal of his previous reasoning.

In first dealing with the detail he says that anything which performs the *function* of a diaphragm *is* a diaphragm.

In dealing with the principle he says, if there *is a diaphragm* performing the *function* of a *diaphragm*, it is a diaphragm.

Let us hope none will ever be so absurd as to deny the last proposition.

Clearly his Lordship, in here protecting the "principle," has (doubtless unconsciously) murdered the remainder of his reasons. This was the very essence of the defendants' case. A *diaphragm* which "performs the function of a diaphragm" was not present—so much for the principle.

Now as regards his authority,

Mr. Justice North says the "decision of Lord Justice Fry in the case he decided seems to me to cover the present case." That is just what it does *not* do.

There was in that case a partition or separater between the speaker and the carbon, and it pressed upon the carbon when spoken to. It was (although not what Edison meant) "a *diaphragm* performing the *functions* of a diaphragm." But in the present case there was not! Where, therefore, is the authority?

As regards the tension regulator, Mr. Justice North says that Mr. Conrad Cooke said that "hard carbon is not appreciably compressible." Mr. Conrad Cooke said nothing of the kind. What he said was, that when good contact was made with the hard carbon no amount of pressure would appreciably alter its resistance. As regards his Lordship's next assertion, that a billiard ball, "if dropped from a sufficient height," is "compressed to half its diameter." Would some of your readers say how far it would have to drop? Possibly his Lordship means that it would break in half and thus be half its original diameter.

As regards conductivity, his Lordship is wisdom itself. He says, "again it is said that hard carbon is not semi-conductive, because it is a good conductor. But this also is a question of degree." Quite so. It is only a question of degree between a silver wire and a clothes line. But seriously, anyone having a rudimentary knowledge of electrical science cannot misunderstand what Edison meant by semi-conductive. And permit me to say, nothing was made more clear to Mr. Justice North in evidence. It was what one would term a partial conductor powdered (that is, plumbago, lamp black, or metallic oxide (?)) and mixed with an *insulator*, and thus producing when done a "semi-conductor."

Mr. Justice North also says that "Mr. Imray's evidence is clear that there is no difference in operation between the plumbago points there described and the carbon used in the Blake, the Ader, the Gower-Bell, &c." In the first place, Mr. Imray never said he had seen or tried one in operation, and in the second place, he could not if he would. It is impracticable, whatever it may seem theoretically. Those who doubt let them try, as I have.

Dealing with the question of being commercially useful, and having been in practical use, perhaps his Lordship makes the most astounding statement of all, and I give it in conclusion. He said, "There is direct evidence on the subject. Sir William Thomson *proves* that he has seen transmitters constructed in some of the forms Edison described, in actual use, and has himself used them," and that "any one of them could be used as a commercial instrument." Sir William Thomson did not *prove* anything of the kind. He made the assertion that he had seen one in use in Lombard Street, but when challenged by Mr. Bigham he had to admit that it was provided with a hard carbon contact—in fact, a Blake transmitter—only he always considered the Blake instrument was Edison's. So much for Sir W. Thomson's *proof*. On this point his Lordship also says that Professor Forbes stated "He could not say if they would act practically as he had not tried them." How can Mr. Justice North justify this when he has Professor Forbes's own description of two experiments during the trial with the gum rubber-plumbago contact before him, in which he stated he (Professor Forbes) could not obtain the slightest sound? Perhaps the climax of his Lordship's ingenuity and *impartiality* is reached (as it should be) in the last few lines where (because Mr. Conrad Cooke stated that Edison's tension regulators would not work without a diaphragm) his Lordship said, "It was obviously his view that if it was *not taken away* they would act."—What taken away?—The *function* to vibrate or the *diaphragm?*

There are many details in Edison's transmitters, such as resonant tube, box, diaphragm, tension regulators, springs, adjusting screws, &c.—Edison mentions the function of everyone. His diaphragm is to vibrate; but so is his tube. He says, "The vibrations are given either to the resonant tube or deflected to the diaphragm." Edison thus distinctly mentions the fact that the tube will vibrate. Still he disclaims all other details or combination of parts, and claims only the combination of the diaphragm or tympan with the tension regulator. Mr. Justice North says because it performs this function (vibration) it is not what Edison says it is, but something else. His Lordship evidently understands Edison's instrument better than Edison understood it himself.

F. T. H.